

TEL001 – Summary of the April 2006 Repair Work
19-Sep-2006
Jamie Blowers, Technical Division

This is a brief summary of the work done to repair TEL001 (pressure vessel RSB-0536) in April 2006, during the extended shutdown. We attempted to capture the hours on job # 395 (project/task 30/30.9.1.1.5.1.1). According to TDCharge we logged 340.5 hours on this job. In addition 74.5 hours were logged on Machine Shop job V8559.

The work entailed identifying the location of the leak and then opening the magnet up so that repairs could be completed. This work entailed opening up the single-phase, and so the cryo-safety panel required that a pressure test be completed. There is a more detailed “blog” of the chronology of the work attached to this report.

Documentation:

- Incoming inspection traveler (TR-308871) issued 18-Apr-2006
- Discrepancy Report number 4349
- TEL001 repair “blog”
- One picture of the repaired tubes. Notice that flex-hose was used, and we included a G10 block for support (see note from Cryo-safety review memo). In addition, numerous pictures are located in the network folder below. Each folder is dated and contains a brief statement of what the pictures are:
 \\tdserver1\project\proeng\MagnetPhotos\TEL\TEL001, or via <http://tdserver1.fnal.gov/project/proeng/MagnetPhotos/TEL/TEL001>
- Cryo-safety review memo (Bill Cooper)
- Pressure test plan (Bill Soyars)
- Pressure test permit and record
- Pressure vessel note amendment (proposal by Bill Soyars)
- Various drawings, mostly ones from IHEP. There is one from AD which shows the voltage tap configurations.

In addition, we also used the AD borescope/video system to record (on VHS tape) the finding of the leak and broken bellows, and the visual inspection of the welds after the repairs were completed. Todd Johnson should have the tape.

As of the writing of this note I do not see a new or updated pressure note on the ES&H Section web page.



**Fermi National Accelerator Laboratory
Batavia, IL 60510**

**TEVATRON ENERGY SAVER DIPOLE
INCOMING INSPECTION
TRAVELER**

Reference Drawing(s):

Project # / Task #: 30/30.9.1.1.5.1.1

Job#: 395

Released by: Dennis Gaw

Magnet/Device Series: TEL

Date: 4/18/2006 10:50:39 AM

Scan Pages: / 9

Prepared by: M. Cullen

| Title | Signature | Date |
|------------------------------|--|---------|
| TD / E&F Process Engineering | Bob Jensen Bob Jensen/Designee | 1/28/04 |
| TD / E&F Assembly | Dan Smith Dan Smith/Designee | 1/28/04 |
| TD / E&F Fabrication Manager | John Carson John Carson/Designee | 1/28/04 |

Revision Page

| Revision | Step No. | Revision Description | TRR No. | Date |
|-----------------|-----------------|---|----------------|-------------|
| None | N/A | Initial Release | N/A | |
| A | | Incorporated traveler into Document Control System. Converted to computer file and updated. Changed specification designator from ES to TR. | 0856 | 6/18/98 |
| B | | Changes to comply with current traveler format and standards. Updated to current production floor practices | 0868 | 8/18/98 |
| C | 3.2 | Inserted Radiation and Lead Paint Surveys. | 0944 | 2/3/00 |
| D | 2.2 | Update DSR | 1601 | 1/28/04 |
| | 6.2 | Update DSR | | |

Ensure appropriate memos and specific instructions are placed with the traveler before issuing the sub traveler binder to production.

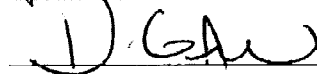
1.0 General Notes


- 1.1 White (Lint Free) Gloves (Fermi stock 2250-1800) or Surgical Latex Gloves (Fermi stock 2250-2494) shall be worn by all personnel when handling all product parts after the parts have been prepared/cleaned.
- 1.2 All steps that require a sign-off shall include the Technician/Inspectors first initial and full last name.
- 1.3 No erasures or white out will be permitted to any documentation. All incorrectly entered data shall be corrected by placing a single line through the error, initial and date the error before adding the correct data.
- 1.4 All Discrepancy Reports issued shall be recorded in the left margin next to the applicable step.
- 1.5 All personnel performing steps in this traveler must have documented training for this traveler and associated operating procedures.
- 1.6 Personnel shall perform all tasks in accordance with current applicable ES&H guidelines and those specified within the step.
- 1.7 Cover the product/assembly with Green Herculite (Fermi stock 1740-0100) when not being serviced or assembled.

2.0 Parts Kit List

- 2.1 No Parts Kit List required.

- 2.2 Update DSR


Lead Person


Date

3.0 Hazard Survey

- 3.1 Perform a Radiation Survey and record results below. Describe Location and Level of any "HOT" spots.

.07

mR @ 1 Foot

Note(s):

If device is more than Radiation Class 1, reject acceptance of the device, unless there is written authorization from the Section Head.

If written authorization is given attach to the traveler.

D. Cade
Technician(s)

4-18-2006
Date

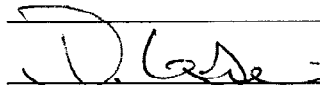
- 3.2 Send a sample of the paint to ES & H for lead testing, unless previously cleared by the ES & H group.



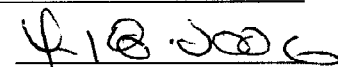
No Lead
ES & H Approved



Lead Based Paint
Follow Precautions Below



Technician(s)

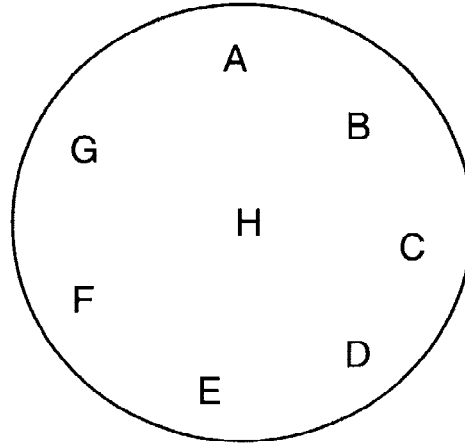


Date

4.0 Electrical Inspection

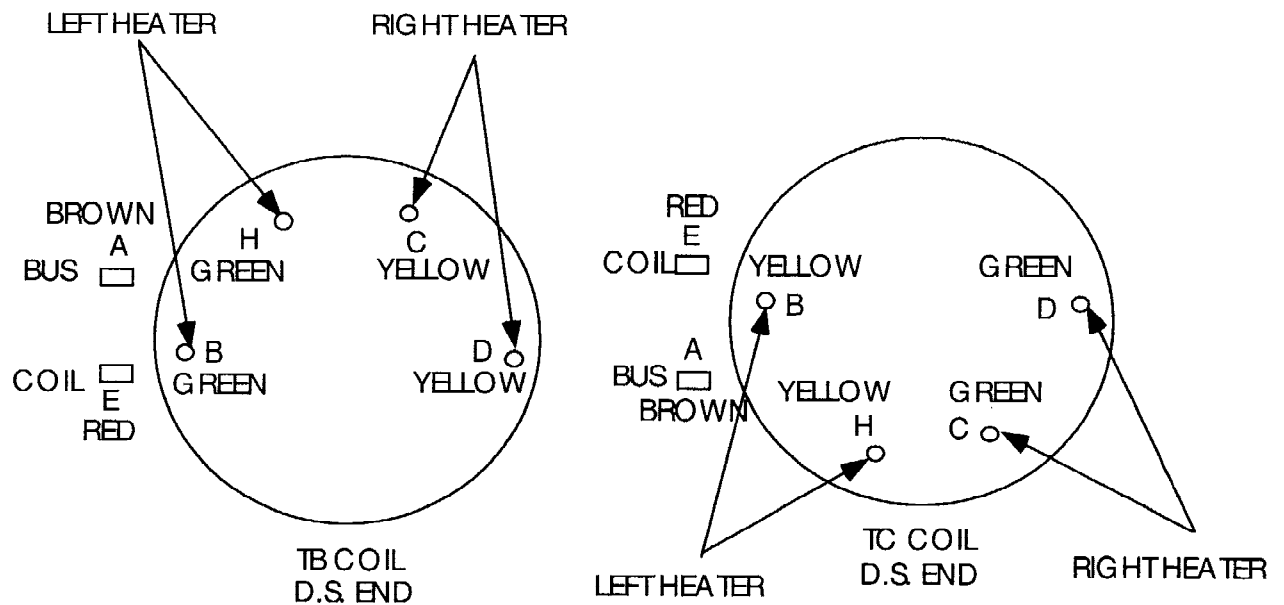
Pin Connector #1 or Instrumentation Connector.

Instrumentation Pin Connector



A= Buss Lead
E= Coil Lead

C-D= R Heater 28-32 Ω
B-H= L Heater 28-32 Ω



- 4.1 Perform an Acceptance Electrical using diagrams on previous page and record results below.

Test Not Required (Attach request/authorization to forgo Electrical Inspection) ☐

| Electrical Test | Equipment Serial Number | Limit | Actual Measurement | Pass | Fail | Out of Tolerance |
|--|-------------------------|-------------------------|--------------------|------|------|------------------|
| Coil Resistance Short Buss to Coil at the U.S. End | 32-155 | 4.674 to 4.786 Ω | 2006m Ω | | | |
| LS @ 1 KHz | 84618 | 22.11 to 22.61 mH | 235 mH | | | |
| Q @ 1 KHz | | 2.13 to 2.27 | 2.2 | | | |
| LS @ 100 Hz | | | 287 mH | | | |
| Q @ 100 Hz | | | 1.9 | | | |
| Right Heater Resistance C-D | X | 27 to 30 Ω | X Ω | X | | X |
| Left Heater Resistance H-B | | 27 to 30 Ω | X Ω | X | | X |
| Continuity Test Buss-A | X | $\leq .8 \Omega$ | X Ω | X | | X |
| Continuity Test Coil-E | | $\leq .8 \Omega$ | X Ω | X | | X |
| Hipot Coil to Ground | A20503 | $<.5 \mu A @ 500 VDC$ | μA | | | |
| Hipot Buss to Ground | | $<.5 \mu A @ 500 VDC$ | X μA | X | | X |
| Hipot Coil to Buss | | $<.5 \mu A @ 500 VDC$ | X μA | X | | X |

Inspector

Date

RING @ 100V OK
D.G.W.

5.0 Vacuum InspectionTest Not Required (Attach request/authorization to forgo Vacuum Inspection) ☐

5.1 Perform a Vacuum Leak check of the following systems and record results below using MD-124720 and ES-124233.

5.1.1 Evacuate vacuum shell and beam tube.

5.1.2 Verify fixture set-up to be leak free including bagging both ends.

5.1.3 Pressurize in the following order per ES-124233, 1 phase, 2 phase and N2 shield systems to 30 PSIG Helium.

5.1.4 Record scale units before and after each system pressurization.

| PART NO. | DATE TIME | OPERATOR'S LAST NAME | SCALE UNITS BEFORE HELIUM PROBE | SCALE UNITS WHILE ENCLOSURE FLOODING | DETERMINATION OF MINIMUM DETECTABLE LEAK | | | |
|------------|-----------|----------------------|---------------------------------|--------------------------------------|--|------|------|----------------------|
| FINAL TEST | | | | | MDS ÷ ((Response - Bckgnd) ÷ Leak Value) = MDL | | | |
| | | GAW | 20X1 | 20X1 | 2 | 36X5 | 20X1 | 385X10 ⁻⁸ |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

Comments:

Inspector D GAWDate 4/14/06

| PART NO. | DATE TIME | OPERATOR'S LAST NAME | SCALE UNITS BEFORE HELIUM PROBE | SCALE UNITS WHILE ENCLOSURE FLOODING | DETERMINATION OF MINIMUM DETECTABLE LEAK | | | |
|--------------------|-----------|----------------------|---------------------------------|--------------------------------------|--|------|------|----------------------|
| PRE-PRESSURE TEST | | | | | MDS ÷ ((Response - Bckgnd) ÷ Leak Value) = MDL | | | |
| | 4-14-06 | GAW | 20X1 | 20X1 | 2 | 36X5 | 20X1 | 385X10 ⁻⁸ |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| PART NO. | DATE TIME | OPERATOR'S LAST NAME | SCALE UNITS BEFORE HELIUM PROBE | SCALE UNITS WHILE ENCLOSURE FLOODING | DETERMINATION OF MINIMUM DETECTABLE LEAK | | | |
| POST-PRESSURE TEST | | | | | MDS ÷ ((Response - Bckgnd) ÷ Leak Value) = MDL | | | |
| | 4-18-06 | GAW | 20X1 | 20X1 | 2 | 36X5 | 20X1 | 385X10 ⁻⁸ |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

Tev:

6.0 Acceptance

6.1 Photograph the magnet, and store in OnBase.




Inspector



Date

6.2 Update DSR



Lead Person



Date

7.0 Production Complete

- 7.1 Process Engineering verify that the Tevatron Energy Saver Dipole Incoming Inspection (TR-301871) is accurate and complete. This shall include a review of all steps to ensure that all operations have been completed and signed off. Ensure that all Discrepancy Reports, Nonconformance Reports, Repair/Rework Forms, Deviation Index and dispositions have been reviewed by the Responsible Authority for conformance before being approved.

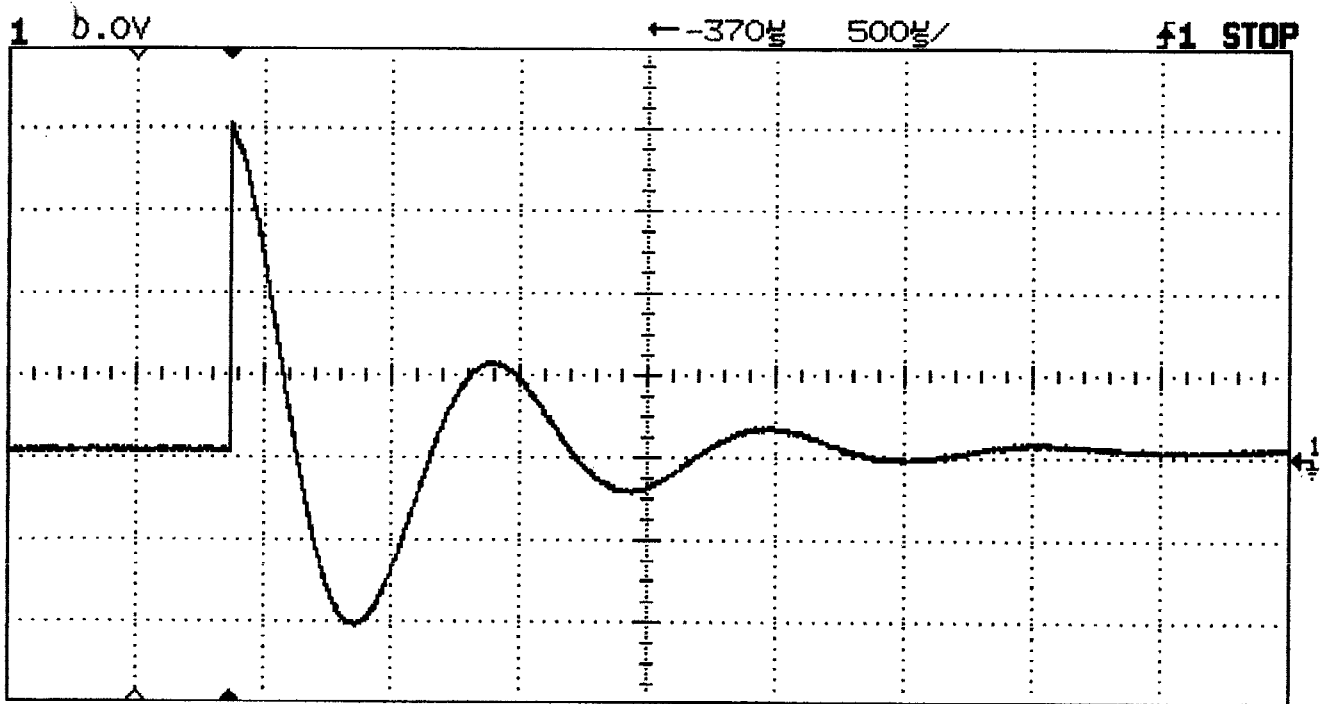
Comments:

A more detailed writeup can be found in
TD Note TD-06-056.


Process Engineering/Designee

9/21/2006
Date

11:24:10 Tue Apr 18, 2006



| | State | Volts/Div | Position | Cplg | BW Lim | Inv | Probe |
|--------|-------|-----------|----------|------|--------|-----|-------|
| Chan 1 | On | 20.00 V | -20.00 V | DC | Off | Off | 10:1 |
| Chan 2 | Off | 100.0mV | 0.000 V | DC | Off | Off | 1:1 |

| | Mode | Main Time/Div | Main Delay | Time Ref | Delayed Time/Div | Delayed Delay |
|------------|--------|---------------|------------|----------|------------------|---------------|
| Horizontal | Normal | 500.0us/ | -370.0us | Left | ----- | ----- |

| Trigger Mode | Source | Level | Holdoff | Slope | Couplg | Reject | NoiseRej |
|--------------|--------|---------|---------|-------|--------|--------|----------|
| AutoLvl | Ch 1 | 1.875 V | 200.0ns | Pos | DC | HF | On |

Display Mode: Normal

| | |
|----------------------|-----------|
| Traveler | 301871 RD |
| Step # | 4.1 |
| Magnet Serial Number | T2001-D |
| Technician | DGee |
| Page Count | 1 of 1 |



FERMILAB
ENGINEERING NOTE

SECTION

PROJECT

SERIAL-CATEGORY

PAGE

SUBJECT

TEL I CHECK-OUT

NAME

DAVID WOLFF + BOB HIVELEY

DATE

5/26/06

REVISION DATE

| | | | | | | |
|---|--|--------------------------------|--------|--------|--------|---------|
| Checked for signals at TPS+TP14 from 9 program | TP4 | TP9 | TP13 | TP7 | TP15 | TP8 |
| | UL | LL | COIL | DI/DT | QV | CURRENT |
| X | LNG 1 -100mV/-210mV -210/-550 45 AMPS | +200mV/+40mV 0/+200 | ✓ ✓ | ✓ ✓ | ✓ ✓ | ✓ ✓ |
| X | LNG 2 +10mV/-160mV -50mV/-210mV 45 AMPS | +250mV/+100mV +300mV/+140mV | ✓ ✓ | ✓ ✓ | ✓ ✓ | ✓ ✓ |
| X | SHORT 1 -350mV -350mV 180 AMPS | -1.0V -850mV | ✓ ✓ | ✓ ✓ | ✓ ✓ | ✓ ✓ |
| X | SHORT 2 0/+850mV 0V/+850mV 180 AMPS | +100mV/-550mV +250/-450mV | ✓ ✓ | ✓ ✓ | ✓ ✓ | ✓ ✓ |
| X | SHORT 3 -600mV -600mV 180 AMPS | -600mV -600mV | ✓ ✓ | ✓ ✓ | ✓ ✓ | ✓ ✓ |
| X | SHORT 4 -850mV -850mV 180 AMPS | -850mV -800mV | ✓ ✓ | ✓ ✓ | ✓ ✓ | ✓ ✓ |
| X | MAIN SOL +750mV/+50mV +650mV/-50mV | +280mV/-200mV +300mV/-200mV | ✓ ✓ | ✓ ✓ | ✓ ✓ | ✓ ✓ |

Auto Reverse:

LONG 2: OK

LONG 4: OK

Measured $V_{d,ps}$
from .01 - 9.0 program

SHORT 1: OK

SHORT 2: OK

SHORT 3: OK

SHORT 4: OK

Look for
SIGNALS
DURING
1V Ref
turn-on

Traveler Title:

Tevatron Energy Saver Dipole Magnet Incoming Inspection

Specification No:

301871

Revision:

D

DR No:

4349

Step No:

5.1

Drawing No:

1128-01-00-00-00SB-11

Routing Form No:

xx

Serial No:

TEL001

Rework ID:

0

Discrepancy Description:

Traveler instructs to, Perform a Vacuum Leak check of the following systems and record results below using MD-124720 and ES-124233.
Actual leak testing discovered a leak in the helium return line. The single phase leaks to the insulating vacuum.

Originator:

Dennis Gaw

Date:

6/8/2006 9:06:06 AM

Cause of Nonconformance:

The bellows pressure damage probably due to quench.

Responsible Authority:

Sasha Makarov

Date:

6/8/2006 10:11:14 AM

Disposition:

1. Cut the window through the vacuum vessel and nitrogen shield.
2. Cut bellows on both supply and return lines.
3. Replace bellows with the braided flexible SS hoses.
4. Single phase pressure test with nitrogen at 290 PSI for 10 minutes.
5. Single phase vacuum leak check.
6. Weld the nitrogen shield patch.
7. Install back the superinsulation.
8. Weld the vacuum vessel patch.
9. Vacuum test.

Disposition verify notes: Performed all step described in the disposition. TEL 1 single pahse leak has been repaired. All systems are hekium leak tight.

Responsible Authority:

Sasha Makarov

Date:

6/8/2006

Corrective Action to Prevent Recurrence:

None

Responsible Authority:

Sasha Makarov

Date:

6/8/2006

Corrective Action/Disposition Verified By:

Dennis Gaw

Date:

12:00:00 AM

Will Configuration be affected?: ☐ YES ☒ NO

Identified problem area:

☒ Material ☐ Manpower ☐ Method ☐ Machine ☐ Measurement

Reviewed By:

Bob Jensen

Date:

6/9/2006

This note is an attempt to document the details of the TEL #1 (TEL001) leak investigation and subsequent repair.

09-Mar-06

The AD mechanical guys found the mystery leak in F4; it was TEL #1.

<http://www-bd.fnal.gov/cgi-mach/machlog.pl?nb=tev06&action=xe&page=58&time=06:13:48>

It is assumed that this popped as a result of the F4 quench which ended the last store before the current shutdown. We note that TEL #1 had electrical problem repaired in TD in 2000.

13-Mar-06

TEL #1 was received at IB2, and leak checking began. Within a day Denny Gaw had located a leak on the single-phase return line. Todd Johnson also brought over a borescope, and video was taken of the innards of the helium space. It was discovered that the inner bellows liner on the helium inlet line was quite deformed (it, however, did not leak). There is a video tape of the investigation.

15-Mar-06

A “meeting of the minds” took place between TD and AD personnel. It was agreed that the plan of attack was to send the device to VMS and have it opened up. We will repair both lines, since we are going to be inside.

17-Mar-06

TEL001 sent from IB2 to VMS. They soon began the work of opening up the vacuum space to get to the helium lines. Their job number was V8559 (they used task number 20.20.1.1.21 for some reason).

23-Mar-06

Magnet had been opened up at VMS. They had removed the outer SS plate, the super-insulation, the copper shield, and the two helium pipes. They also cut out the double-bellows, and did the weld prep for the new parts to be welded onto the pipes. The names of the machinists are in the table at the bottom of this blog; the primary guy was Phil Cowen.

27-Mar-06

Tom Peterson and Sasha looked at the magnet at VMS. It was determined that we should replace the double bellows with flex hose, which should provide a more robust design for squirm protection during thermal changes and quenches.

xx-yy-06

TEL001 was moved from VMS to IB2

xx-Apr-06

The flex hoses were welded onto the helium pipes, and the parts were brought over to IB2. I do not know for sure who did the welding, but the records in TDCharge show that

Mike Reynolds did work on job V8559, so it's likely he was the welder. I also do not know if the parts were leak checked.

07-Apr-06

The Cryo Safety Committee met around the device, and concluded that an official visual inspection, leak check, and pressure test should be done as a result of the rewelding on the helium lines.

11-Apr-06

The flex hoses and pipes were welded onto the device by Bob Williams. Todd Johnson brought over his camera so that we could do a visual inspection of the welds to verify full penetration. The first inspection showed that there was some areas on both lines which did not have full penetration, so Bob Williams did a second pass. The second inspection showed improvement in the return line, but the feed line actually looked a little worse. It was agreed that this was as good as we were going to get them.

The 2nd video inspection, done after the second pass of welding, was recorded on the AD tape.

12-Apr-06

Pump down started for a leak check. Initial results looked promising (i.e. no major leaks were found).

13-Apr-06

Final leak check was completed, and passed by Jan Szal.

14-Apr-06

Began setting up for the pressure test, which is planned for Monday 17-Apr at 4pm. We used the copper lines and regulator from ICB, and the pressure gage and relief valve from Bill Soyers. The setup was slightly different than the cartoon in Bill's test plan document, in that the return line was capped (actually the ball valve was simply closed), and the pressure relief was T'd off of the pressure gage on the intake line.

17-Apr-06

Pressure test successfully completed. It was held at 290 psig for 10 minutes. Those present were: Rich Ruthe, Bill Soyers, Jamie Blowers, and Sasha Makarov, with door 'guards' Bob Jensen, Dan Smith, Junior Jones and Wayne Ostrom.

18-Apr-06

Pressure testing tooling was removed, and pump down for leak checking was started. By the afternoon the vessel was certified as leak tight, both in the helium space and in the nitrogen space. By the end of the day the outer plate had been removed. There should be pics.

19-Apr-06

The copper shield was welded into position, and super-insulation was applied. There should be pics at each step.

21-Apr-06

The final leak check was done, and passed. We have asked AD if they would like to do any electrical testing.

24-Apr-06

Dan Wolf and another AD person were over today and were running electrical tests. I asked them to send us a summary of their work. They are going to send Denny a schematic of the electrical connections.

25-Apr-06

Two Russian gentleman were over today to put the end can onto the TEL. They encountered some problems, not connected to anything TD had done, but they were working through them. One problem is that the wire for the wire scanner had been burned up, and it had coated a ceramic with metal which caused a short. They had repaired that problem, and were hoping to have the magnet ready to do by the end of the day (it was going to be a late day for them if they did that).

27-Apr-06

Presumably the AD work on TEL001 has been completed, as it has now left IB2.

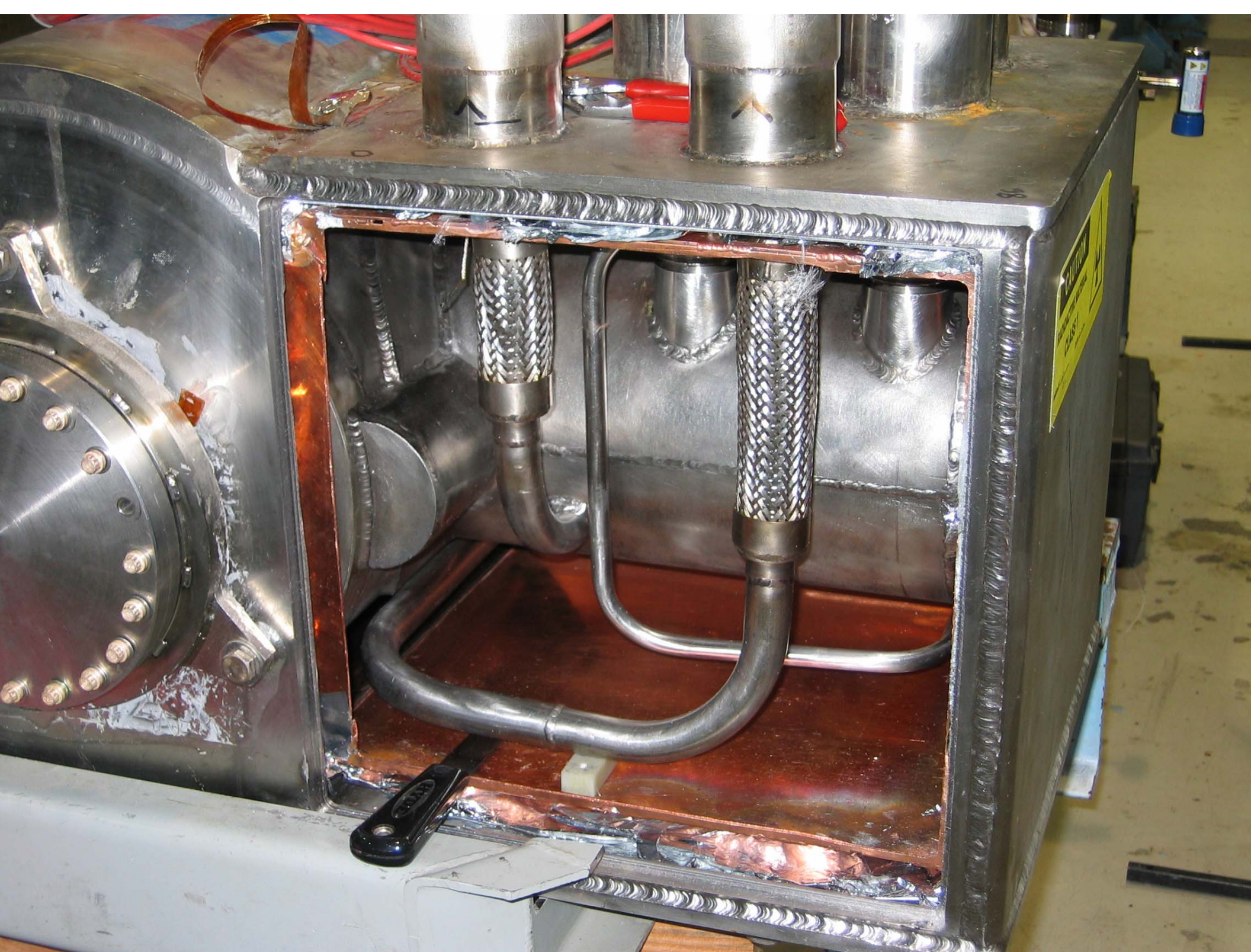
Here's a breakdown of the hours spent on job 395 (415 hours total):

| year | month | WBScode | proj | Blowers_Jamie | Gardner_Thomas | Gaw_Dennis | Makarov_Alexander | Robatzek_William | Sanchez_Sergio | Smith_Daniel | Szal_Jan | Williams_Robert |
|------|-------|----------------|------|---------------|----------------|------------|-------------------|------------------|----------------|--------------|----------|-----------------|
| 2006 | 03 | 30.9.1.1.5.1.1 | 395 | 4 | 18 | 26 | 25 | | 2 | | | |
| 2006 | 04 | 30.9.1.1.5.1.1 | 395 | 17 | 35 | 36 | 44 | 15 | 52 | 23 | 5 | 19 |
| 2006 | 05 | 30.9.1.1.5.1.1 | 395 | 1 | 17 | | | 2 | | | | |

Total: 340.5

| year | month | WBScode | proj | Berens_Michael | Cowan_Phillip | Green_Gerald | Hagler_Edward | Larson_Sherri | Penson_Carl | Reynolds_Michael |
|------|-------|----------------|-------|----------------|---------------|--------------|---------------|---------------|-------------|------------------|
| 2006 | 03 | 20.20.1.1.21 | V8559 | | 7 | | | | | |
| 2006 | 04 | 20.20.1.1.21 | V8559 | 3 | 53 | 2 | 2 | | 4 | 3 |
| 2006 | 06 | 30.9.1.1.5.1.1 | V8559 | | | | | 1 | | |

Total: 74.5





April 10, 2006

To: Roger Dixon
Head, Accelerator Division
From: W. E. Cooper
Chairman, Tevatron Cryogenic Safety Review Panel
Subject: TEL-1 and TEL-2 Magnets

Dear Roger,

Friday April 7, four members of the Tevatron Cryogenic Safety Review Panel, accompanied by W. Soyars, J. Volk, and people who would perform repairs, looked at the TEL-1 magnet and the repairs proposed for it. While the detailed mechanism for failure of piping within its vacuum space is not fully understood, our judgment is that the proposed repairs adequately address a similar future failure. The end of one internal pipe moved downward until it caught on a convolution of double-walled bellows. The internal of the two bellows walls was subsequently torn. The external wall of the bellows remained intact. This type of failure will be avoided in the future by shortening the pipe and replacing the bellows with a flex hose. The flex hose will limit downward motion of piping. A stand-off may also be added to control motion, but we regard that as optional. We note that no leak to vacuum was observed at this location.

The second, similar but shorter, internal line does not appear to have suffered the same type of bellows failure. Nevertheless, a leak was observed in the vicinity of its bellows. The specific location of the leak has not been determined. The second set of bellows has been removed, and will also be replaced with a flex hose.

Since the location of the leak in the second line has not been determined and could be through a weld, the Panel recommends that in-process inspection of welds be included in the repair procedure. We consider in process inspection, a pressure test, and a helium leak check to be adequate alternatives to radiography of the welds. That combination, plus the design change of replacing bellows with flex hoses, should ensure that the TEL-1 magnet can be operated safely.

We note that similar issues appear to exist for TEL-2, which we were told has already been installed. Since we understand that the design of TEL-2 is identical to that of TEL-1, we believe that a similar failure should be anticipated. The Panel has been told that symptoms of a leak to vacuum are already present in TEL-2. Our understanding is that no immediate remedial action is planned for TEL-2.

Present Tevatron approval prohibits powering of magnets with personnel present in the tunnel. For that reason, the Panel regards a leak to vacuum as an operational issue, but not an issue of personnel safety. We recommend that you consider operational consequences of a failure to vacuum and develop a plan to address them.

Regards,
W. E. Cooper
On behalf of the Tevatron Cryogenic Safety Review Panel

cc:

A. Makarov
D. Harding
J. Blowers
W. Soyars

J. Volk

J. Anderson, Jr.

R. Schmitt

Review Panel Members

(W. Cooper, P. Hurh, R. H. Lewis, T. Peterson, C. Sylvester)

Repaired TEL 1 Helium Vessel Pressure Test at IB2

Bill Soyars (AD/Cryo)

April 11, 2006

Introduction

The TEL 1 solenoid magnet pressure vessel (Fermilab RSB536; note that some earlier documentation referred to it as RSB 520) originally was fabricated at the Institute for High Energy Physics in Protvino, Russia. This device has seen service in the Tevatron at F48 since 2000. The rated MAWP is 260 psia. Repairs were required to fix a He-to-insulating vacuum leak on a bellows, and to fix a squirmed bellows. Both failed double-walled bellows were removed and replaced with braided flex hose.

The pressure test will be similar to the one conducted 10/6/00 for TEL 1. The pressure test will be performed at a 110% of maximum allowable working pressure (MAWP) or 290 psig in order to re-certify this vessel. The pressure test will follow ES&H Chapter 5034 Rev. 3/2001 guidelines and a Pressure Test Permit (shown in Exhibit B) completed. A 0-600 psig pressure gauge (calibrated 9/30/04) will be used for the pressure test and connected directly to the vessel in plain sight of operator. All personnel are required to read, understand and sign-off on the procedure, enclosed below.

Materials Required

| | |
|---|------|
| O-ring sealed Goddard fitting caps. (2) | have |
| Caps for main current leads (2) | |
| Cap for small current leads (1) | |
| Cap for Kautzky port (1) | have |
| 350 psig relief. | have |
| 0-600 psig gage. | have |
| Nitrogen cylinder with regulator | |

Precautions of Pressure Test

- A door guard and signs will be positioned to prevent access to test area during the pressure test
- All personnel will wear a hard hat and safety glasses

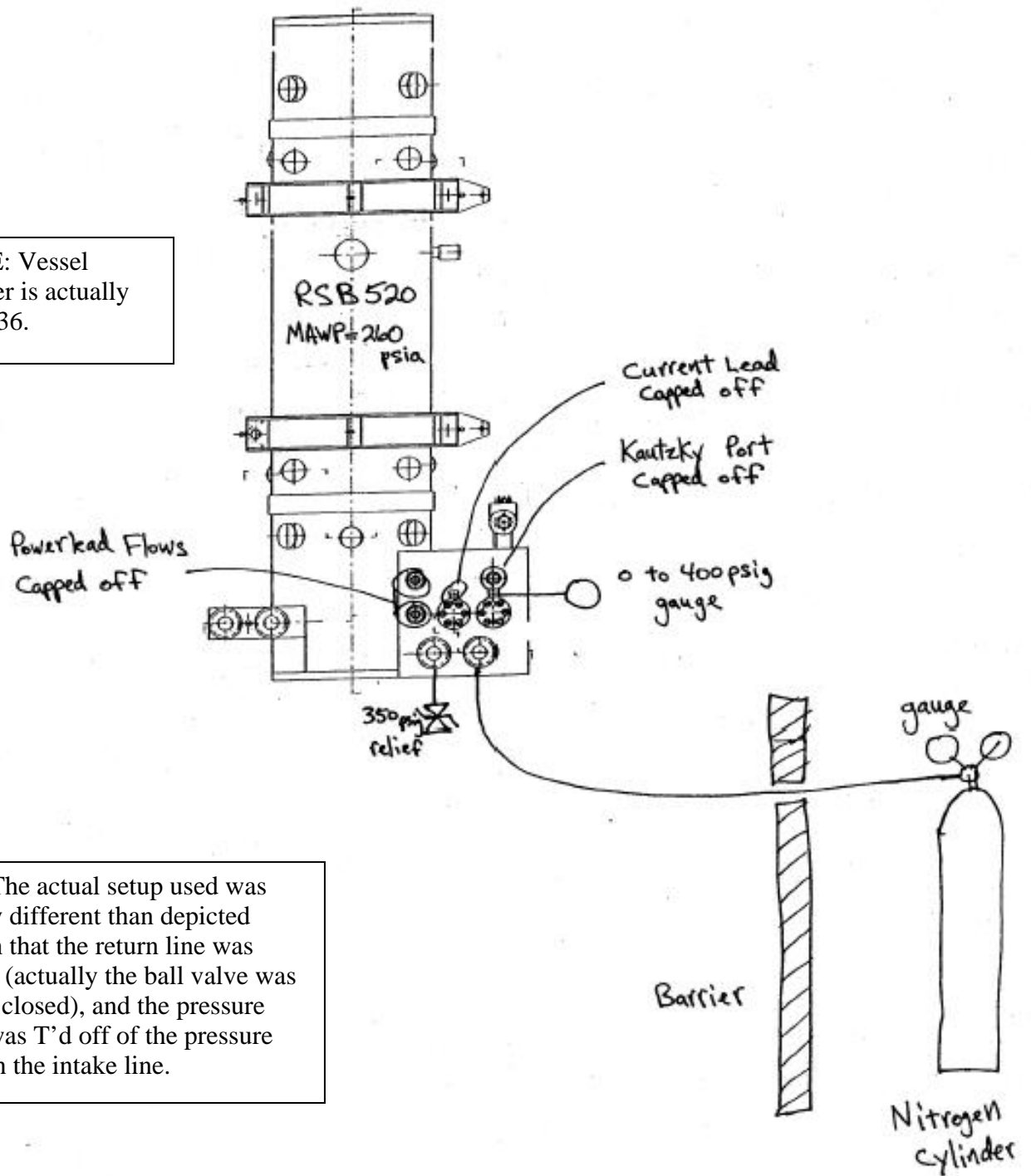
Procedure of Pressure Test

1. Cap three TEL 1 lead vents.
2. Cap Kautzky relief port
3. Cap two bayonet Goddard fittings.
4. Install safety relief valve with 350 psig set point as shown in Figure 1.
5. Install 0-600 psig test gage as shown in Figure 1.
6. Connect, high pressure nitrogen gas cylinder with regulator to bayonet port as shown in Figure 1.
7. Gradually pressurize the vessel to $\frac{1}{2}$ of ultimate test pressure (per ASME Boiler Code UG-100). Since Test Pressure is 290 psig, this value is 145 psig.
8. Check for leaks in the manifold assembly using snoop.
9. If a leak is detected, tighten the fitting and continue.
10. After all leaks are tight, increase the pressure to in increments of about 30 psi (about 10% of ultimate test pressure). If leak found, depressurize and fix.
11. Hold at 290 Test Pressure for 10 minutes.
12. Reduce pressure to 260 (90% of Test Pressure) and inspect for leaks.
13. After inspection, relieve the vessel of its pressure gradually through a vent valve at bottle manifold. Disconnect pressure source.

Reviewed by: _____
(Richard Ruthe, TD ES&H)

Date: _____

NOTE: Vessel
number is actually
RSB536.



Note: The actual setup used was slightly different than depicted here, in that the return line was capped (actually the ball valve was simply closed), and the pressure relief was T'd off of the pressure gage on the intake line.

Figure 1. Schematic of TEL1 Pressure Test at IB2.

The test coordinator or his/her designee has reviewed this procedure with me and I understand the procedure, associated pressure test hazards and required precautionary actions. I will follow the requirements of this procedure and hazard analysis or notify my supervisor if I am unable to do so.

[illegible]



Fermilab

Date: April 11, 2006

EXHIBIT B
Pressure Testing Permit*

Type of Test: ☐ Hydrostatic ☒ Pneumatic

Test Pressure 290 psig Maximum Allowable Working Pressure 260 psia psig

Items to be Tested

Beam-Beam Compensation Solenoid (TEL 1) following repair of leaking bellows Pressure Vessel RSB 536 (some earlier documentation referred to this device as RSB520).

Location of Test IB2 Date and Time 4/17/06 1600

Hazards Involved

Pressurized vessel and equipment failure due to over-pressurization. Flying objects.

Safety Precautions Taken

Area to be cleared of personnel. Sentries and signs posted to prevent access into Test Area during pressure test. Doors locked if possible.

Safety relief valves to protect the vessel and equipment against over-pressurization.

Special Conditions or Requirements

Pressure test per Chapter 5034 of FESHM. See attached schematic.

Qualified Person and Test Coordinator
Dept/Date

Jamie Blowers Bill Soyars
Jamie Blowers x2800 / Bill Soyars x3362
TD 4/17/06 / AD-Cryo 4/17/06

Division/Section Safety Officer
Dept/Date

Richard Ruthe
Richard Ruthe
TD/ES&H 4/17/06

Results

Successfully held at 290 psig for 10 minutes.

Witness

Richard Ruthe
(Safety Officer or Designee)

Dept/Date

TD ES&H 4/17/06

* Must be signed by division/section safety officer prior to conducting test. It is the responsibility of the test coordinator to obtain signatures.

Amendment 1 to Eng. Note RSB 536 Beam-Beam Compensation Solenoid (TEL1)

B. Soyars
May 15, 2006

Introduction

The TEL 1 solenoid magnet pressure vessel, originally fabricated at the Institute for High Energy Physics in Protvino, Russia, has seen service in the Tevatron at F48 since 2000. Following a room temperature warm-up, a He-to-insulating vacuum bellows leak was found in March 2006. Repairs were required to fix the leak and to fix a second, distorted bellows. The problems are with the double-walled bellows on the bottom portion of the TEL1 He supply and return bayonet connections. Both failed double-walled bellows were removed and replaced with braided flex hose.

This amendment documents the problem analysis and design remedy. It is composed of contributions from many sources: AD/Tevatron, AD/Mech. Supt., AD/Cryo, TD/Fabrication, and the Tevatron Cryo Safety Panel.

Failure Analysis and Design Remedy Summary

The leaking bellows did not reveal external or internal visual damage. Nevertheless, a leak was observed in the vicinity. The specific location of the leak was not determined. Weld quality or porosity is the suspected cause. Other welds in this vicinity were seen to be oxidized, suspected to have been poorly purged during welding. This set of bellows was removed and replaced with a flex hose.

The distorted bellows had its internal wall torn, while the external wall remained intact (and leak tight). We suspect failure was due to insufficient support against internal pressure. It is hypothesized that downward motion allowed convolutions to catch and tear. This set of bellows also was replaced with a flex hose. Similar failure will be avoided by limiting downward motion of piping.

New Flex Hose Design Geometry:

The bellows is braided stainless steel hose with 1.00 ID and 1.58" OD (Flexonics type 401M) with 1" x 0.049 tube ends.

- a) Short bellows on He inlet is 2.75" long.
- b) Long bellows on He return is 5" long.

Compare Flex Hose Specifications to Design Requirements

1. Pressure Rating

- a) Maximum pressure during 1000 GeV Tevatron quench is 180 psia.
- b) Pressure rating of flex hose being added: MAWP = 645 psig.
Max. Test Press. = 965 psig. Nominal burst pressure = 2580 psig.

2. Thermal motion

a) Thermal motion to accommodate as lateral offset on He return:
 $90 \text{ in} \times (2.96 \times 10^{-3}) = 0.26 \text{ in.}$

b) The 5" long flex hose handling this is rated for 1/2" lateral offset, per Flexonics specifications.

3. Axial elongation.

Check axial stretching under full pressure or quench pressure.

- a) Allowable clearance is about 1". Conservatively design for 1/2".
- b) Qualitative assessment: When appreciable internal pressure is applied to a corrugated metal hose, it will elongate unless restrained. Generally, this restraint is provided by a wire braid sheath over the hose. For small diameter hoses, typically the strength of the braid sheath is the limiting factor for resisting pressure. Therefore, if pressure is maintained below rated pressure, the hose is OK not only from pressure containment point of view but also from deflection along its longitudinal axis.
- c) In general, flex hose is quite stiff in this direction. If one can approximate a spring constant k or elasticity modulus E , then dL can be calculated. However, it is difficult to get precise spring constant specification, since braided flex hose parameters typically do not call for hose to see loaded motion in this direction.
- d) Qualitative assessment (approximate): Design for MAWP of 260 psia (1790 kPa) acting on 1" diameter tube. Assume stiffness value (E) for "7-strand steel wire rope" applies to SS braids. (Actual braids are bundles of 8 strands). Assume braid area consists of 0.010" dia. filaments around 1.58 bellows OD.

$$E = 9.72 \times 10^6 \text{ psi}$$

$$\sigma = \frac{F}{A_{\text{braids}}} = \frac{PA}{A_{\text{braids}}} = \frac{260 \cdot \pi / 4 \cdot 1^2}{0.010 \cdot \pi \cdot 1.5} = 4333 \text{ psi}$$

$$\varepsilon = \frac{\sigma}{E} = \frac{4333}{9.72 \times 10^6} = 4.5 \times 10^{-4} \text{ in/in}$$

$$\delta = EL = 4.5 \times 10^{-4} \cdot 5 = 0.002 \text{ in}$$

- e) Conclusion: Very little deflection along longitudinal axis. Its important to note that "slack" in making up outer braid covering probably dominates. But it will be <1/2".

Fabrication quality assurance

1. TD Quality Assurance documentation consists of:

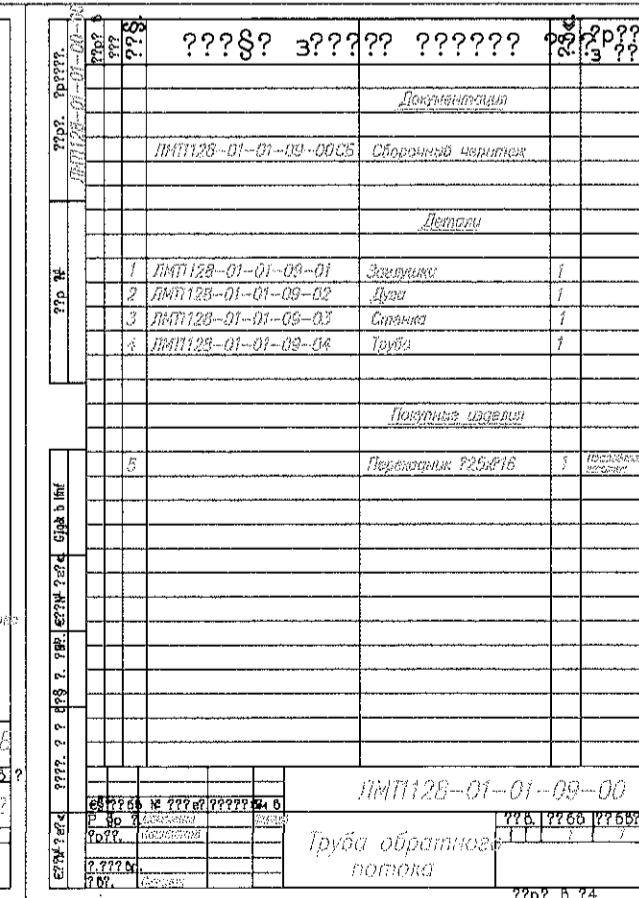
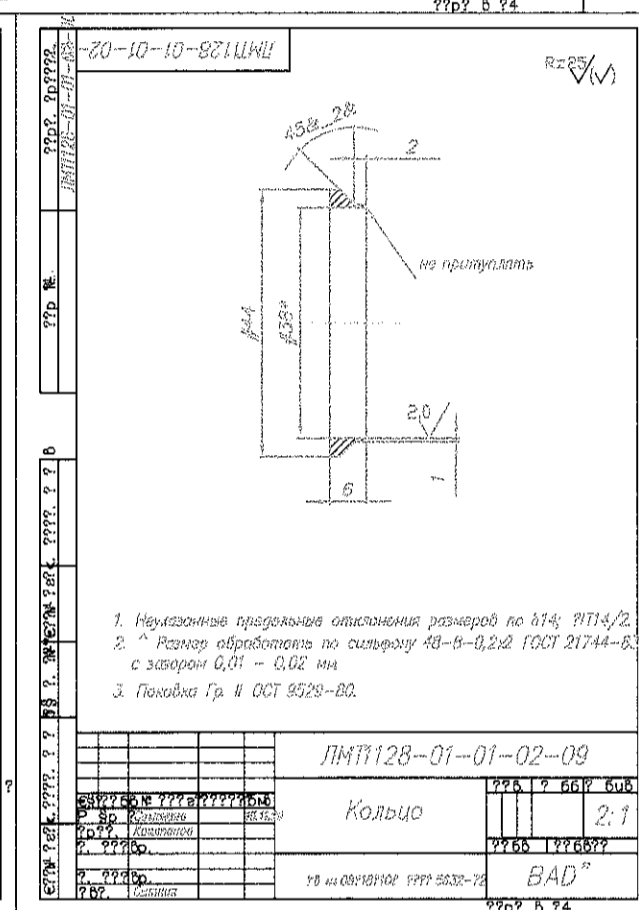
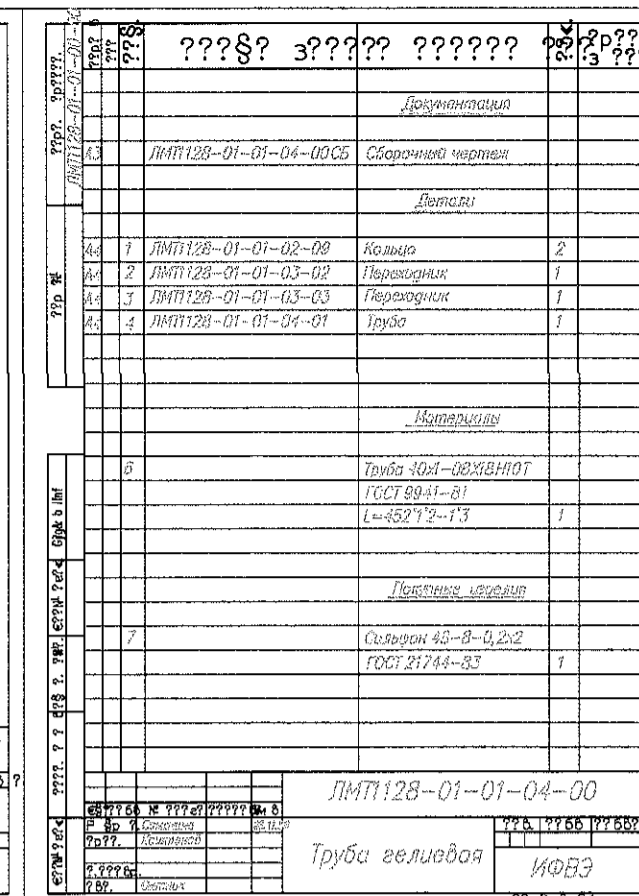
- Incoming Inspection Traveler" (documents the finding of the leak and distorted bellows)
- Discrepancy Reports (documents the work plan for correcting the problems),
- Statement of the work completed (includes the names of the persons doing the work),
- Additional records: visual inspection (recorded on tape) and leak check.

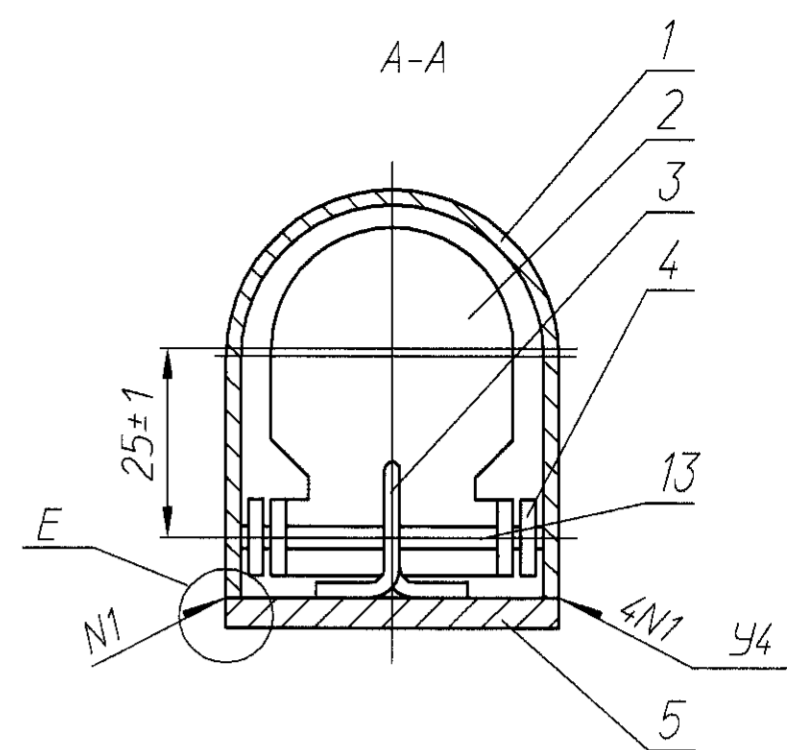
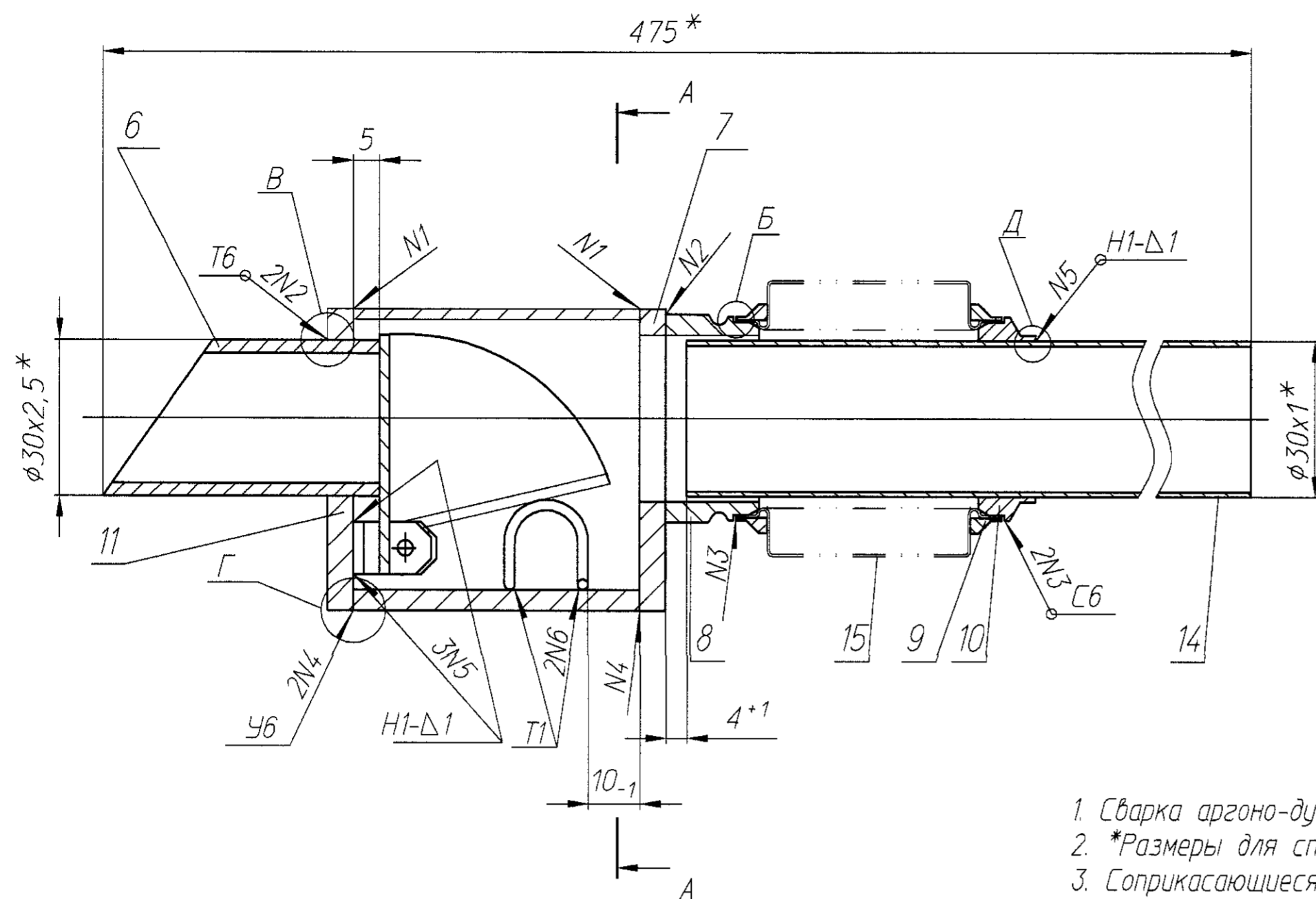
2. Welds

For weld quality assurance, "in-process examination of welding", as part of above TD Quality Assurance documentation, was applied in lieu of radiography. (Ref. B31.3 section 344.7.1.)

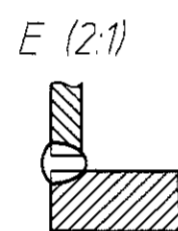
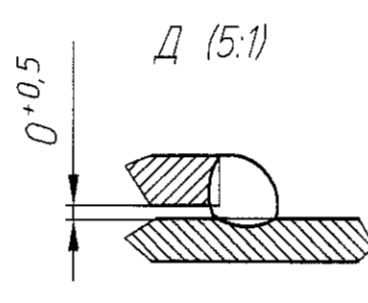
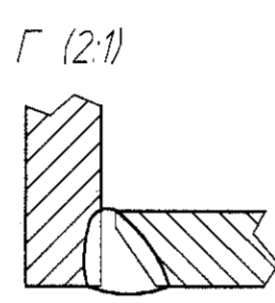
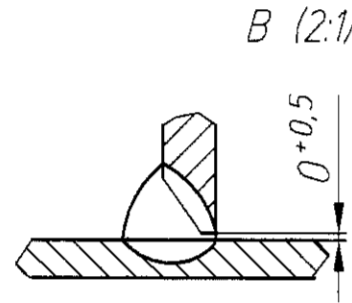
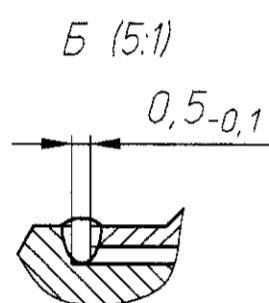
3. Pressure Test

Pressure test to 290 psig (110% of MAWP) was successfully completed on April 11, 2006.





1. Сварка аргоно-дуговая по ГОСТ 14771-76.
2. *Размеры для справок.
3. Соприкасающиеся плоскости деталей поз. 2 и 6 притереть.
4. Сварные швы проверить на герметичность методом обдува по ОСТ 50170-81; класс герметичности - 1



| | | | | | |
|-----------|----------|---------|----------|--|-----------------------|
| | | | | | ЛМТ1128-01-01-02-00СБ |
| Изм./Лист | № докум. | Подпись | Дата | <p style="font-size: 1.2em; font-weight: bold;">Труба аварийного сброса</p> <p style="font-size: 1.2em; font-weight: bold;">Сборочный чертёж</p> | |
| Разраб. | Самохина | | 06.09.99 | | |
| Пров. | Каштанов | | | | |
| Т. контр. | | | | | |
| Н. контр. | | | | | |
| Утв. | Сытник | | | | |
| | | | | Лист | Масса |
| | | | | | |
| | | | | | 1:1 |
| | | | | Лист | Листов |
| | | | | | ИФВЭ |

Формат А3

| Перв. примен. | | Формат | | Зона | Поз. | Обозначение | Наименование | Кол. | Примечание |
|---------------------|-----------|----------|---------|--------|-------------------------|-----------------------|--|------|------------|
| ЛМТ1128-01-01-00-00 | | | | | | | | | |
| | | | | | | | <u>Документация</u> | | |
| Справ. № | A3 | | | | | ЛМТ1128-01-01-02-00СБ | Сборочный чертеж | | |
| | | | | | | | <u>Детали</u> | | |
| | | | | | | | | | |
| | A4 | 1 | | | | ЛМТ1128-01-01-02-01 | Кожух | 1 | |
| | A4 | 2 | | | | ЛМТ1128-01-01-02-02 | Заслонка | 1 | |
| | A4 | 3 | | | | ЛМТ1128-01-01-02-03 | Упор | 1 | |
| | A4 | 4 | | | | ЛМТ1128-01-01-02-04 | Опора | 2 | |
| | A4 | 5 | | | | ЛМТ1128-01-01-02-05 | Боковина | 1 | |
| | A4 | 6 | | | | ЛМТ1128-01-01-02-06 | Труба | 1 | |
| | A4 | 7 | | | | ЛМТ1128-01-01-02-07 | Крышка | 1 | |
| | A4 | 8 | | | | ЛМТ1128-01-01-02-08 | Втулка | 1 | |
| Подп. и дата | A4 | 9 | | | | ЛМТ1128-01-01-02-09 | Кольцо | 2 | |
| | A4 | 10 | | | | ЛМТ1128-01-01-02-10 | Переходник | 1 | |
| | A4 | 11 | | | | ЛМТ1128-01-01-02-11 | Крышка | 1 | |
| Инв. № дубл. | | | | | | | <u>Материалы</u> | | |
| | | | | | | | | | |
| | | 13 | | | | | Проволока 2 Св-04Х19Н9 ГОСТ 2246-70 | | |
| Взам. ш.в. № | | | | | | | L=40 ₁ | 1 | |
| | | 14 | | | | | Труба 30х1-08Х18Н10Т ГОСТ 9941-81 | | |
| | | | | | | | L=353 ₂ | 1 | |
| Подп. и дата | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| Инв. № дубл. | | | | | | ЛМТ1128-01-01-02-00 | | | |
| | Изм. Лист | № докум. | Подпись | Дата | Труба аварийного сброса | | | | |
| | Разраб. | Самохина | | 200799 | | | | | |
| | Пров. | Каштанов | | | | | | | |
| | Нконтр. | | | | | | | | |
| | Утв. | Сытник | | | Лист | Лист | Листов | | |

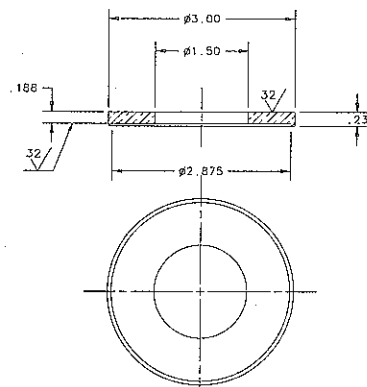
Формат А4

[illegible]

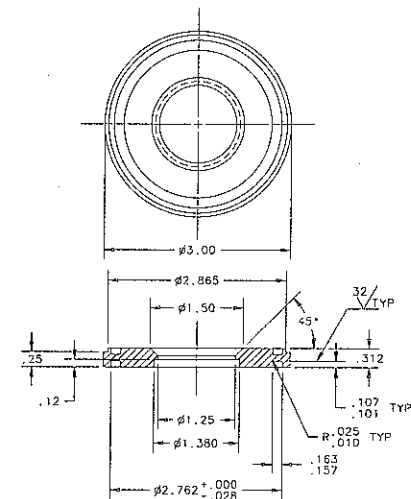
Φορματίτη Α4

| Перв. примен. | | Справ. № | | Подп. и дата | | Инв. № дубл. | | Взам инв. № | | Подп. и дата | | Инв. № дубл. | |
|---------------------|------|----------|------------------------|-------------------------|------|--------------|--|-------------|--|--------------|--|--------------|--|
| ЛМТ1128-01-00-00-00 | | | | | | | | | | | | | |
| Формат | Зона | Поз. | Обозначение | Наименование | Кол. | Примечание | | | | | | | |
| | | | | Документация | | | | | | | | | |
| | | | ЛМТ1128-01-01-00-00СБ | Сборочный чертеж | | | | | | | | | |
| | | | | Сборочные единицы | | | | | | | | | |
| | | 1 | ЛМТ1128-01-01-01-00 | Блок магнитов | 1 | | | | | | | | |
| | | 2 | ЛМТ1128-01-01-02-00 | Труба аварийного сброса | 1 | | | | | | | | |
| | | 3 | ЛМТ1128-01-01-03-00 | Труба гелиевая | 1 | | | | | | | | |
| | | 4 | ЛМТ1128-01-01-04-00 | Труба гелиевая | 1 | | | | | | | | |
| | | 5 | ЛМТ1128-01-01-05-00 | Кожух токоввода | 2 | | | | | | | | |
| | | 6 | ЛМТ1128-01-01-06-00 | ТВ-200 | 2 | | | | | | | | |
| | | 7 | ЛМТ1128-01-01-07-00 | ТВ-1800 | 2 | | | | | | | | |
| | | 8 | ЛМТ1128-01-01-08-00 | Ложемент левый | 1 | | | | | | | | |
| | | 9 | ЛМТ1128-01-01-08-00.01 | Ложемент правый | 1 | | | | | | | | |
| | | 10 | ЛМТ1128-01-01-09-00 | Труба обратного | 1 | | | | | | | | |
| | | | | потока | 1 | | | | | | | | |
| | | 11 | ЛМТ1128-01-01-10-00 | Труба | 1 | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | Детали | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | 14 | ЛМТ1128-01-01-00-01 | Фланец | 1 | | | | | | | | |
| | | 15 | ЛМТ1128-01-01-00-02 | Фланец | 1 | | | | | | | | |
| | | 16 | ЛМТ1128-01-01-00-03А | Полуробчайка правая | 1 | | | | | | | | |
| | | | | ЛМТ1128-01-01-00-00А | | | | | | | | | |
| Изм. Лист | | № докум. | | Подпись | | Дата | | | | | | | |
| Разраб. | | Шувалов | | | | 27.09.99 | | | | | | | |
| Пров. | | Каштанов | | | | | | | | | | | |
| Нконтр. | | | | | | | | | | | | | |
| Утв. | | Сытник | | | | | | | | | | | |
| Сосуд гелиевый | | | | | | | | Лист | | Лист | | Листов | |
| | | | | | | | | 1 | | 1 | | 3 | |
| | | | | | | | | ИФВЭ | | | | | |

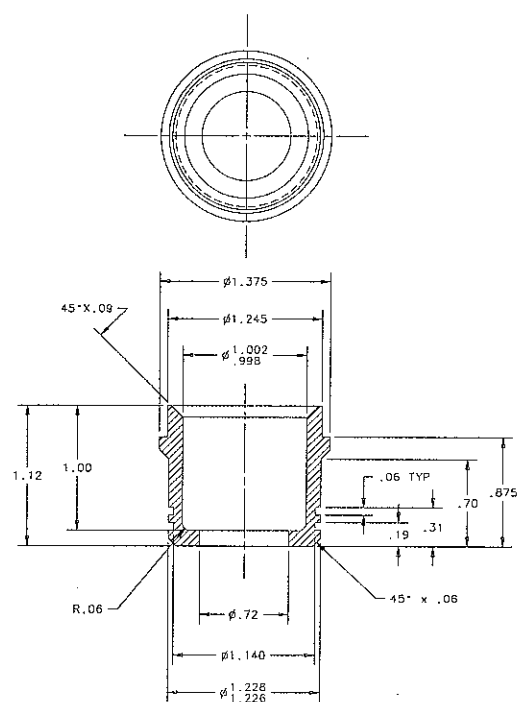
[illegible][illegible]



Detail 4
SCALE 1:1
MATL: BRASS



Detail 3
SCALE 1:1
MATL: G-10



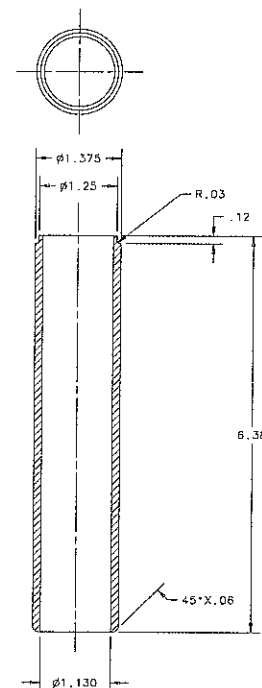
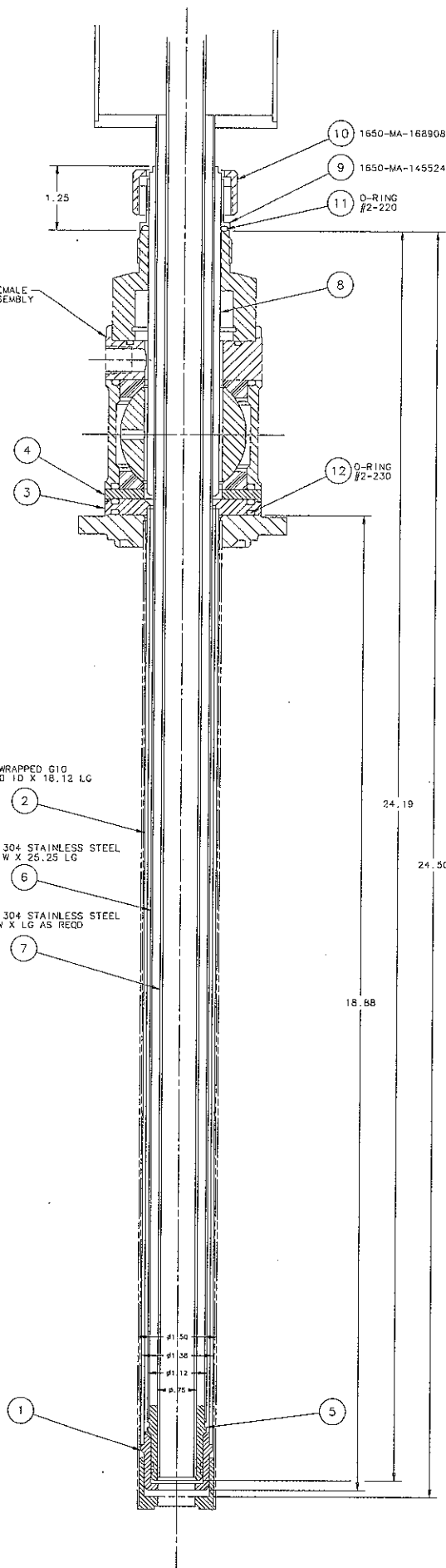
Detail 1
SCALE 2:1
MATL: G-10

EXISTING FEMALE
BAYONET ASSEMBLY

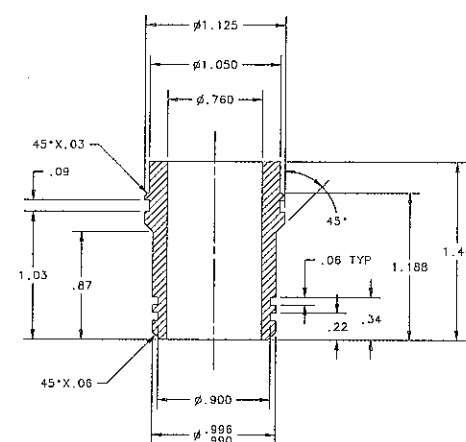
TUBING, SPIRAL WRAPPED G10
1.375 OD X 1.250 ID X 18.12 LG

TUBING, WELDED, 304 STAINLESS STEEL
1.125 OD X .035 W X 25.25 LG

TUBING, WELDED, 304 STAINLESS STEEL
.750 OD X .049 W X LG AS REQD



Detail 8
SCALE 1:1
MATL: 304 SST



Detail 5
SCALE 2:1
MATL: 304 SST

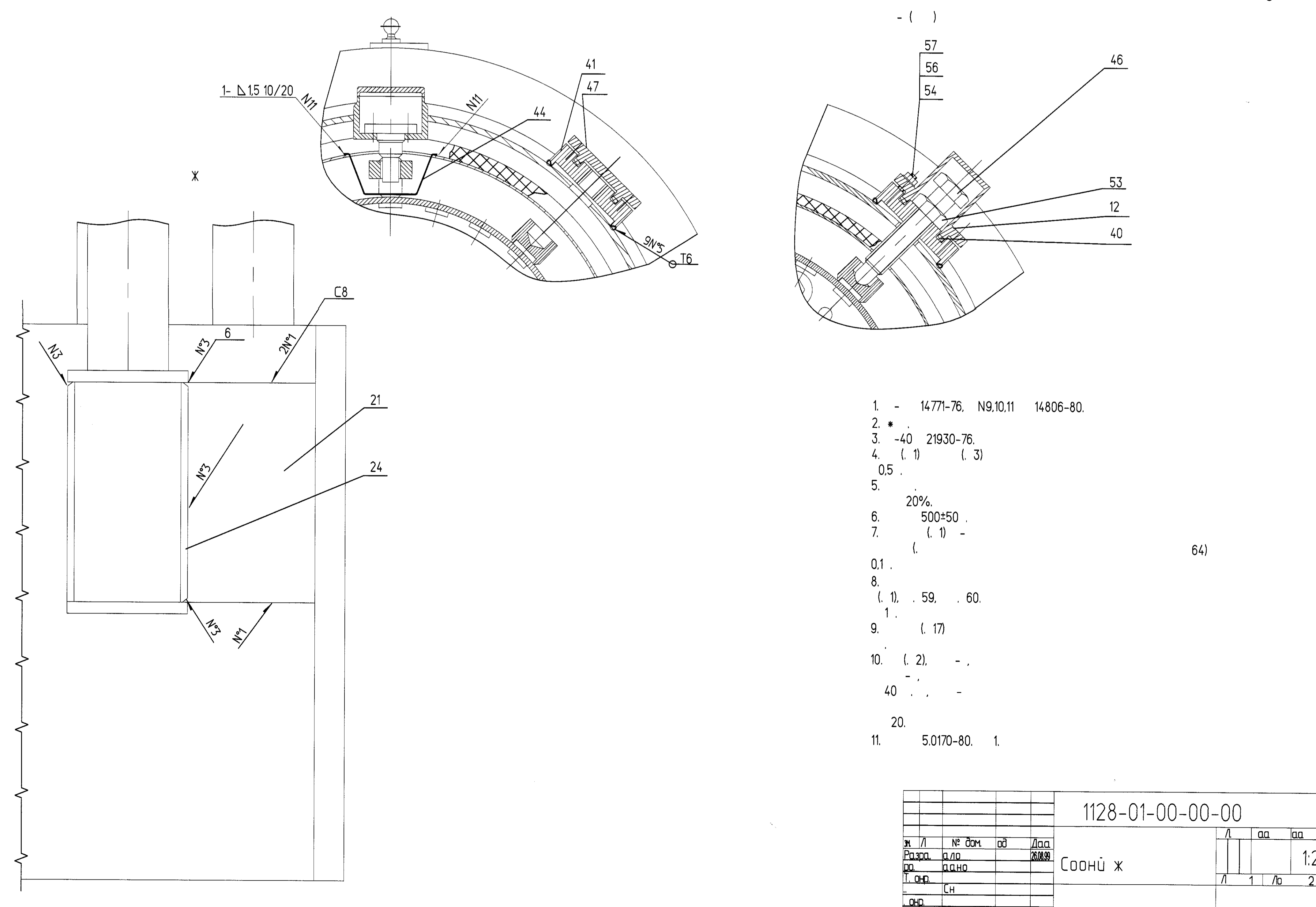
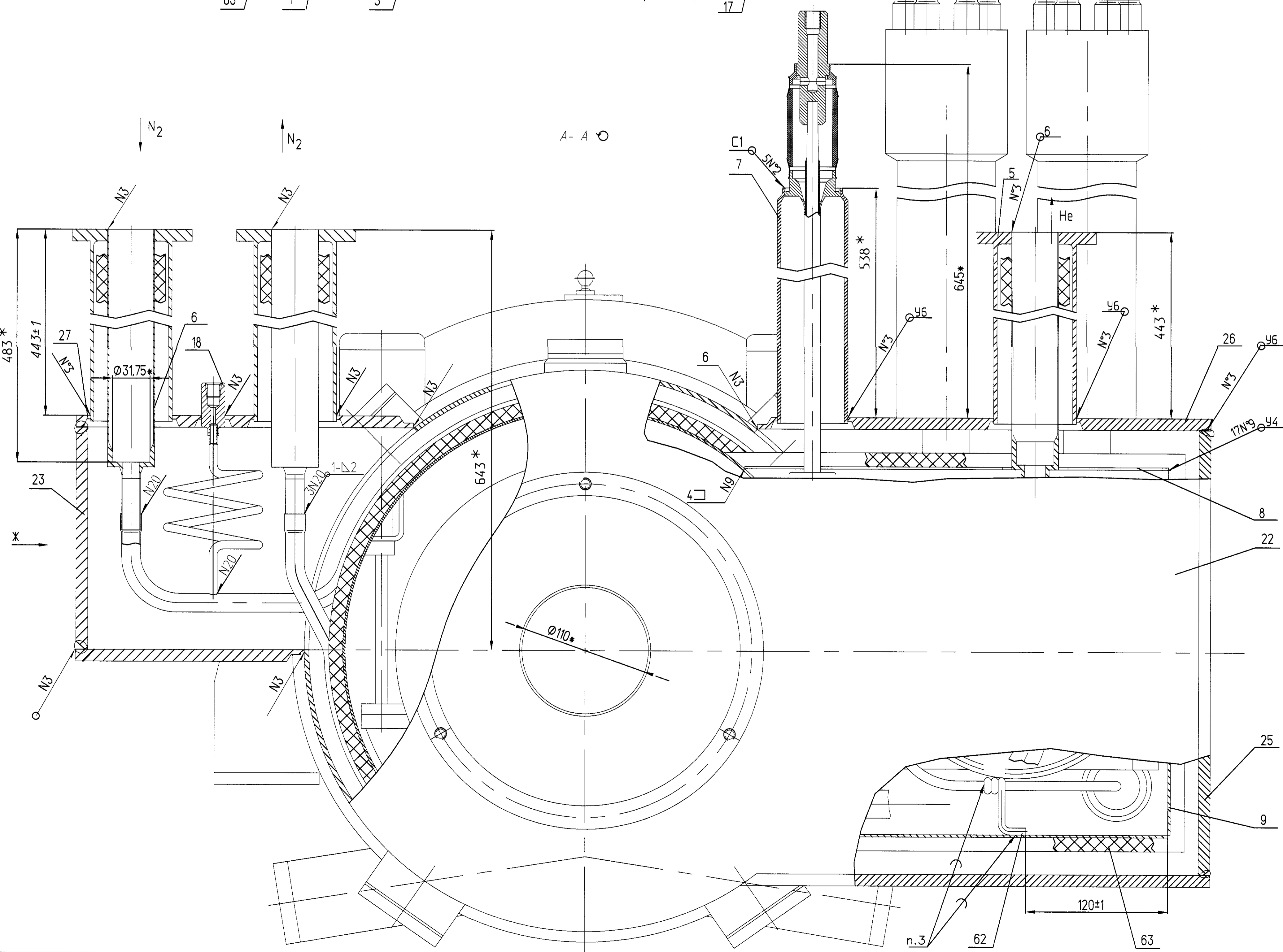
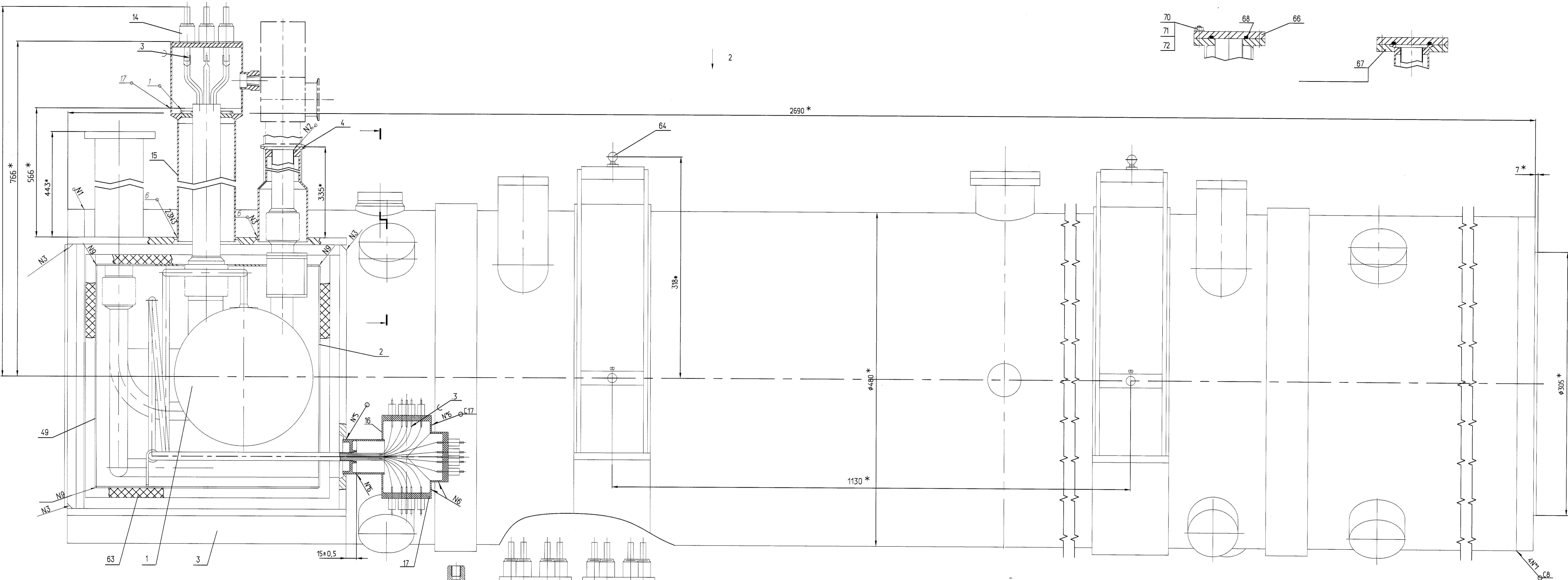
[illegible]

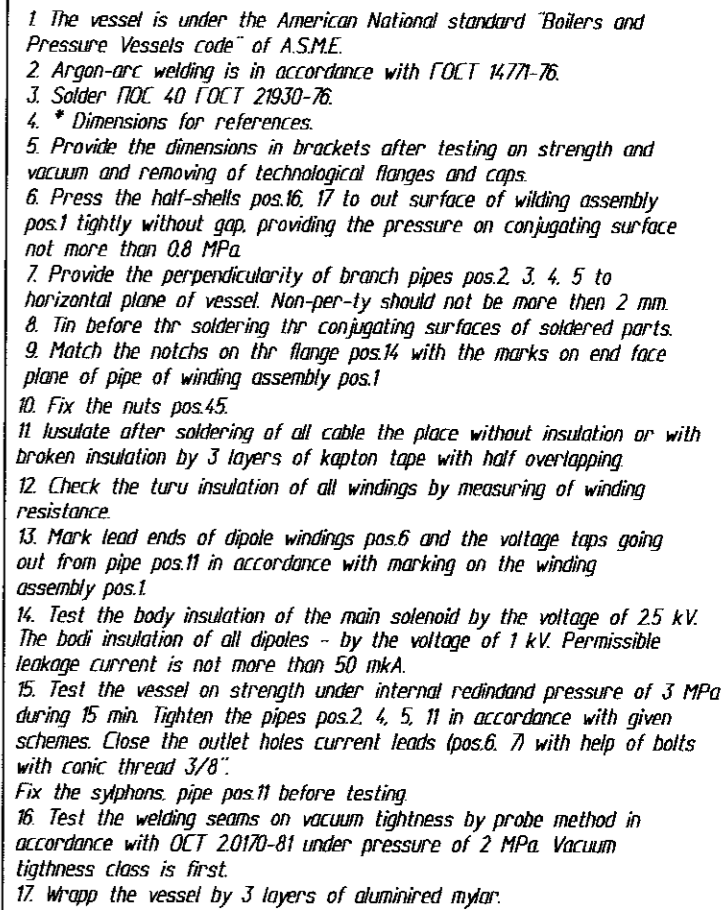
| № п/п | Код | Наименование | Единица измерения | Количество |
|---------------|------------------------|---------------------|-------------------|------------|
| 21 | ЛМТ1128-01-00-00-01 | Сектор | | 1 |
| 22 | ЛМТ1128-01-00-00-02 | Стенка передняя | 1 | |
| 23 | ЛМТ1128-01-00-00-03 | Стенка | | 1 |
| 24 | ЛМТ1128-01-00-00-04 | Боковина правая | | 1 |
| 25 | ЛМТ1128-01-00-00-05 | Стенка | | 1 |
| 26 | ЛМТ1128-01-00-00-06 | Крышка | | 1 |
| 27 | ЛМТ1128-01-00-00-07 | Крышка | | 1 |
| 29 | ЛМТ1128-01-00-00-09 | Фланец | | 1 |
| 30 | ЛМТ1128-01-00-00-10 | Труба | 1 | |
| 31 | ЛМТ1128-01-00-00-11 | Опора | | 4 |
| 32 | ЛМТ1128-01-00-00-12 | Опора | | 4 |
| 33 | ЛМТ1128-01-00-00-13 | Шайба | | 8 |
| 34 | ЛМТ1128-01-00-00-14 | Гайка | | 8 |
| 35 | ЛМТ1128-01-00-00-15 | Крышка | | 8 |
| 36 | ЛМТ1128-01-00-00-16 | Шайба | | 8 |
| 37 | ЛМТ1128-01-00-00-17 | Шпилька | | 8 |
| 38 | ЛМТ1128-01-00-00-17.01 | Шпилька | | 8 |
| 39 | ЛМТ1128-01-00-00-17.02 | Шпилька | | 8 |
| 40 | ЛМТ1128-01-00-00-18 | Прокладка | 8 | |
| 41 | ЛМТ1128-01-00-00-19 | Фланец | 8 | |
| 42 | ЛМТ1128-01-00-00-20 | Крышка | 8 | |
| 43 | ЛМТ1128-01-00-00-21 | Стержень | 1 | |
| 44 | ЛМТ1128-01-00-00-22 | Желоб | 1 | |
| 45 | ЛМТ1128-01-00-00-23 | Гайка | 1 | |
| 46 | ЛМТ1128-01-00-00-24 | Болт | 8 | |
| 47 | ЛМТ1128-01-00-00-25 | Крышка | 8 | |
| 49 | ЛМТ1128-01-00-00-27 | Стенка передняя | 1 | |
| 60 | | Стандартные изделия | | |
| | | Винт В.М5-6gx8.32 | | |
| | | | | ??? |
| 1128-01-00-00 | | | | ??? |

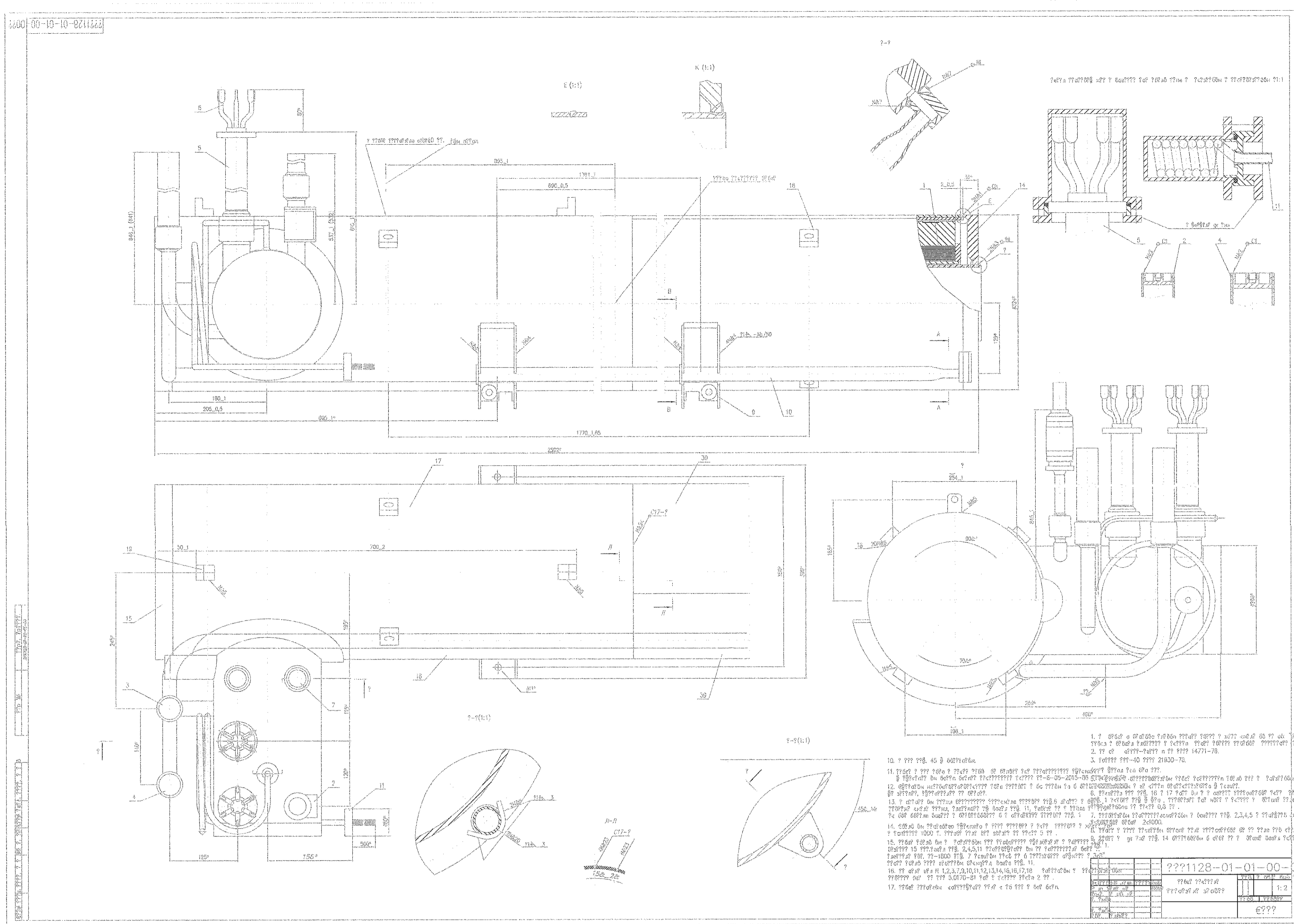
| № п/п | Наименование | Единица измерения | Количество | Примечание |
|-------|--|-------------------|------------|---|
| 51 | Гайка М8-6Н.5 | шт | 8 | |
| 52 | Винт М5-6dх14.66.096 | шт | 2 | |
| 53 | Гайка М20-6Н. 5 | шт | 8 | |
| 54 | Гайка М8-6Н.5 | шт | 32 | |
| 55 | Гайка М10-6Н.32 | шт | 32 | |
| 56 | Шайба 8.01.10.016 | шт | 32 | |
| 57 | Шпилька М8-6dх30.48.016 | шт | 32 | |
| 58 | Шпилька М8-6dх30.48.016 | шт | 32 | |
| 59 | Материалы | | | |
| 60 | Труба 114х2,1 (нерж. сталь американский стандарт) L=2696-5,4 | шт | 1 | *Пост. заказчик *Длину уточнить при сборке |
| 61 | Лист ГПРн 2М | шт | 4 | |
| 62 | Провод ПЩ L=150-2 | шт | 1 | *Пост. заказчик |
| 63 | Изоляция ГТ Р=25кг. | шт | 1 | *Пост. заказчик |
| 64 | Прочие изделия | | | |
| 65 | Реперный знак FNAL | | | |
| 66 | CL-3-SCB | шт | 6 | *Пост. заказчик |

Итого: 1128-01-00-00

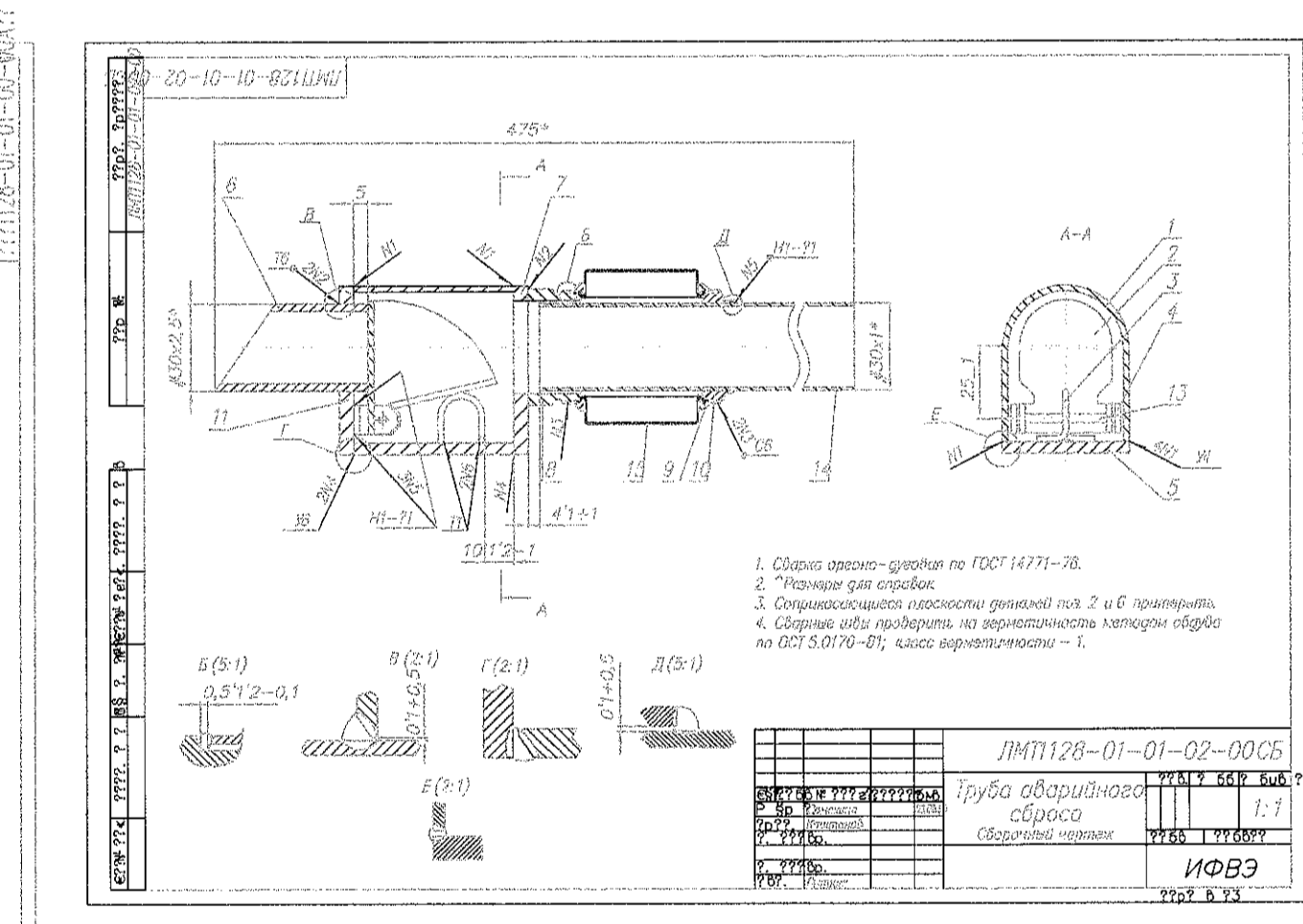
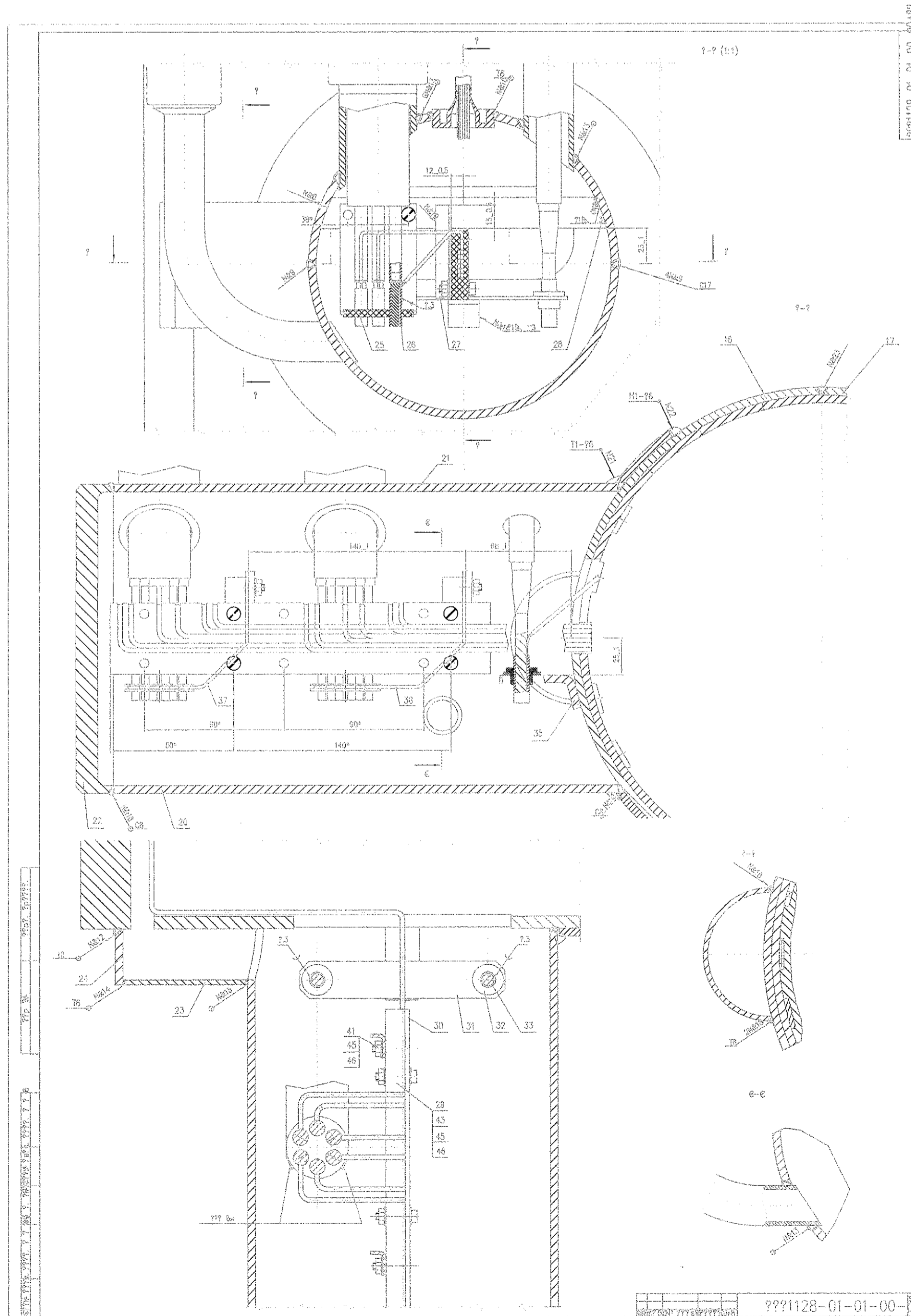
| № п/п | Наименование | Единица измерения | Количество | Примечание |
|-------|------------------------|-------------------|------------|------------|
| 70 | Гайка М8-6Н.5 | | 20 | |
| 71 | Шайба 8.01.10.016 | | 20 | |
| 72 | Шпилька М8-6х30.48.016 | | 20 | |







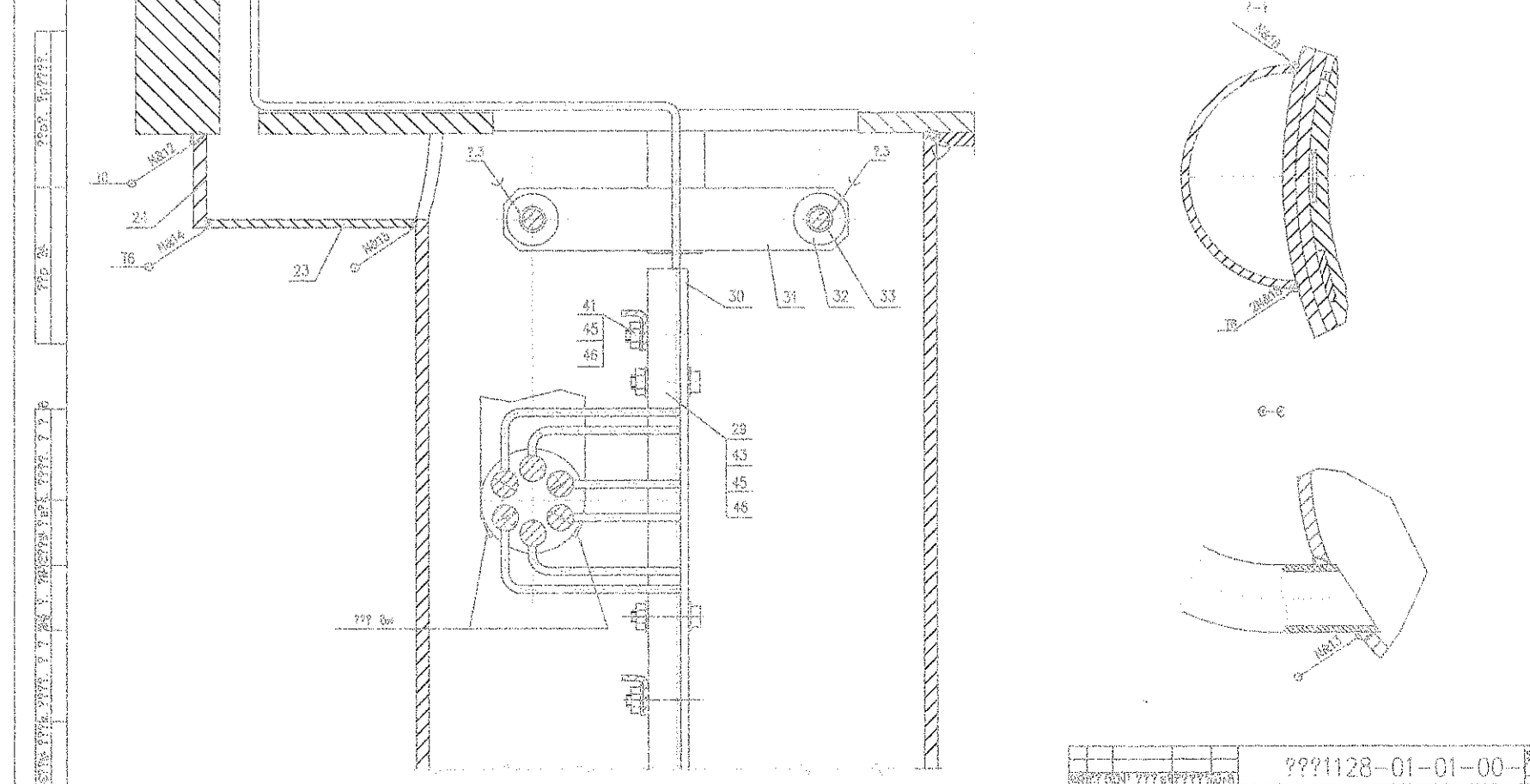
1. The vessel is under the American national standard "Boilers and Pressure Vessels Code" of A.S.M.E.
2. Assembly welding is in accordance with ГОСТ 14771-78.
3. Solder TBC-40 ГОСТ 21830-78.
4. "Dimensions for reference."
5. Provide the dimensions in brackets after fastening on strength and vacuum and removing of technological damage and gaps.
6. Press the ball-shells pos.15, 17 to wet surface of welding assembly part 1 tightly without gaps, providing the pressure on contacting surface not more than 0.5 MPa.
7. Provide the perpendicularity of branch pipes pos.2, 3, 4, 5 to horizontal plane of vessel. Non-perp-ly should not be more than 2 mm.
8. Before the soldering for contacting surfaces of soldered parts, scratch the notch on the flange pos.14 with the marks on end face of the pipe of welding assembly pos.1.
9. Fit the nuts pos.45.
10. Insulate after soldering of oil coils the place without insulation or with broken insulation by 3 layers of asbestos tape with half overlapping.
11. Check the turn insulation of oil windings by measuring of winding resistance.
12. Check the turn insulation of oil windings by measuring of winding resistance.
13. Mark lead ends of single windings pos.6 and the voltage tape going out from pipe pos.11 in accordance with marking on the winding assembly pos.1.
14. Mark lead ends of single windings pos.6 and the voltage tape going out from pipe pos.11 in accordance with marking on the winding assembly pos.1.
15. Test the body insulation of the main assembly by the voltage of 2.5 kV. The body insulation of oil coils - by the voltage of 1 kV. Permissible leakage current is not more than 50 mA.
16. Connect the vessel on strength under internal reduced pressure of 3 MPa during 15 min. Tighten the pipes pos.2, 4, 5, 11 in accordance with given schemes. Close the outlet holes current neck (pos.4, 7) with help of bolts with conical inserts.
17. Test the synchronous pump pos.11 before testing.
18. Test the welding assembly on vacuum tightness by probe method in accordance with ГОСТ 23170-81 under pressure of 2 MPa. Vacuum tightness class is first.
19. Wipe the vessel by 3 layers of abradant paper.



| ЛНП1128-01-01-02-0005 | |
|---|--|
| 1. Сборка осевая - см. рис. по ГОСТ 14771-78. | |
| 2. Проверка при сборке. | |
| 3. Сопоставляемость деталей должна быть по 2 и 3 параметрам. | |
| 4. Сборные узлы проверяются на герметичность в соответствии с требованиями к ним. | |

| ЛНП1128-01-01-02-0005 | |
|---|--|
| 1. Сборка осевая - см. рис. по ГОСТ 14771-78. | |
| 2. Проверка при сборке. | |
| 3. Сопоставляемость деталей должна быть по 2 и 3 параметрам. | |
| 4. Сборные узлы проверяются на герметичность в соответствии с требованиями к ним. | |

| ЛНП1128-01-01-02-0005 | |
|---|--|
| 1. Сборка осевая - см. рис. по ГОСТ 14771-78. | |
| 2. Проверка при сборке. | |
| 3. Сопоставляемость деталей должна быть по 2 и 3 параметрам. | |
| 4. Сборные узлы проверяются на герметичность в соответствии с требованиями к ним. | |



| ЛНП1128-01-01-02-0005 | |
|---|--|
| 1. Сборка осевая - см. рис. по ГОСТ 14771-78. | |
| 2. Проверка при сборке. | |
| 3. Сопоставляемость деталей должна быть по 2 и 3 параметрам. | |
| 4. Сборные узлы проверяются на герметичность в соответствии с требованиями к ним. | |

| ЛНП1128-01-01-02-0005 | |
|---|--|
| 1. Сборка осевая - см. рис. по ГОСТ 14771-78. | |
| 2. Проверка при сборке. | |
| 3. Сопоставляемость деталей должна быть по 2 и 3 параметрам. | |
| 4. Сборные узлы проверяются на герметичность в соответствии с требованиями к ним. | |

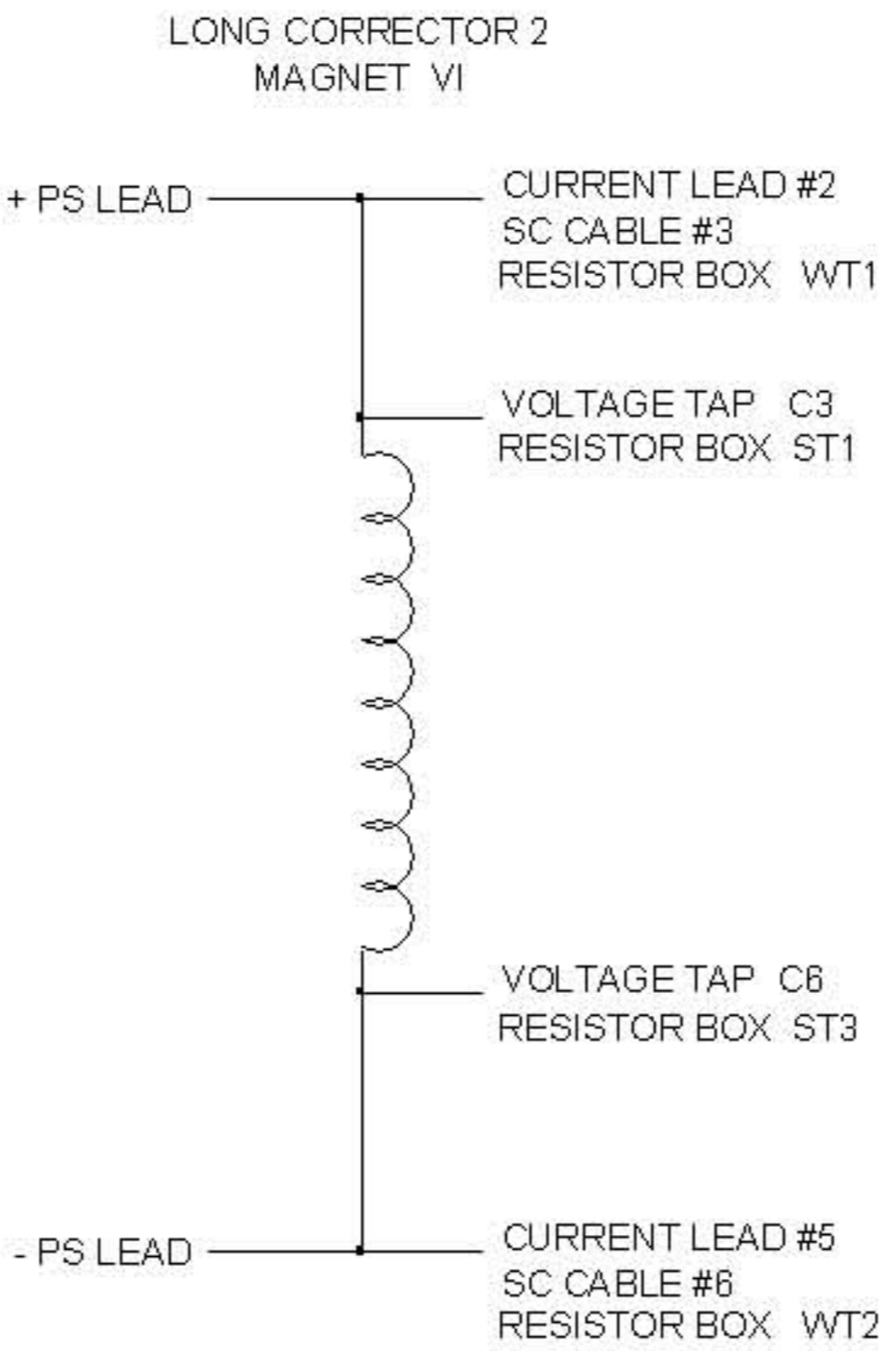
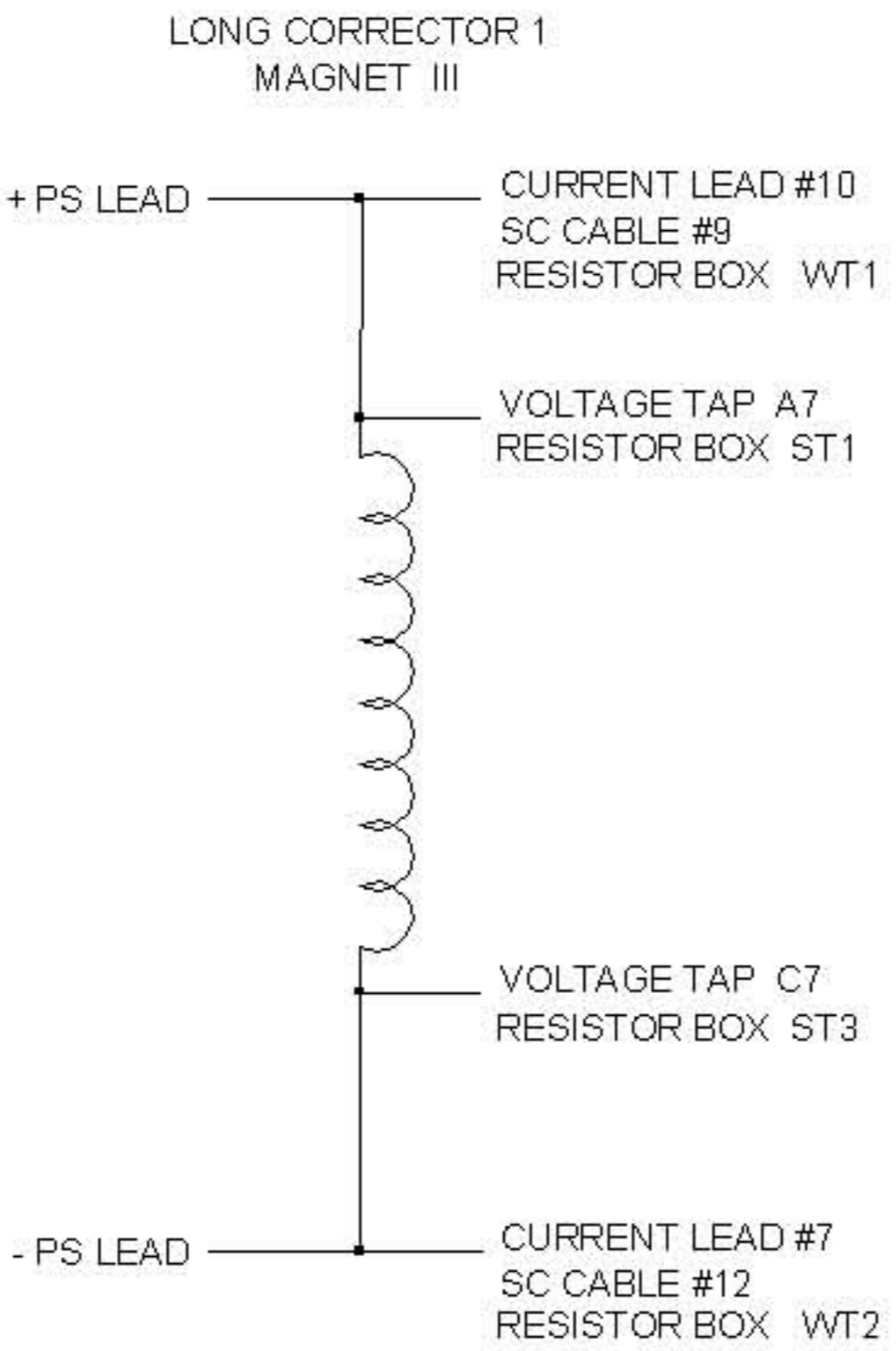
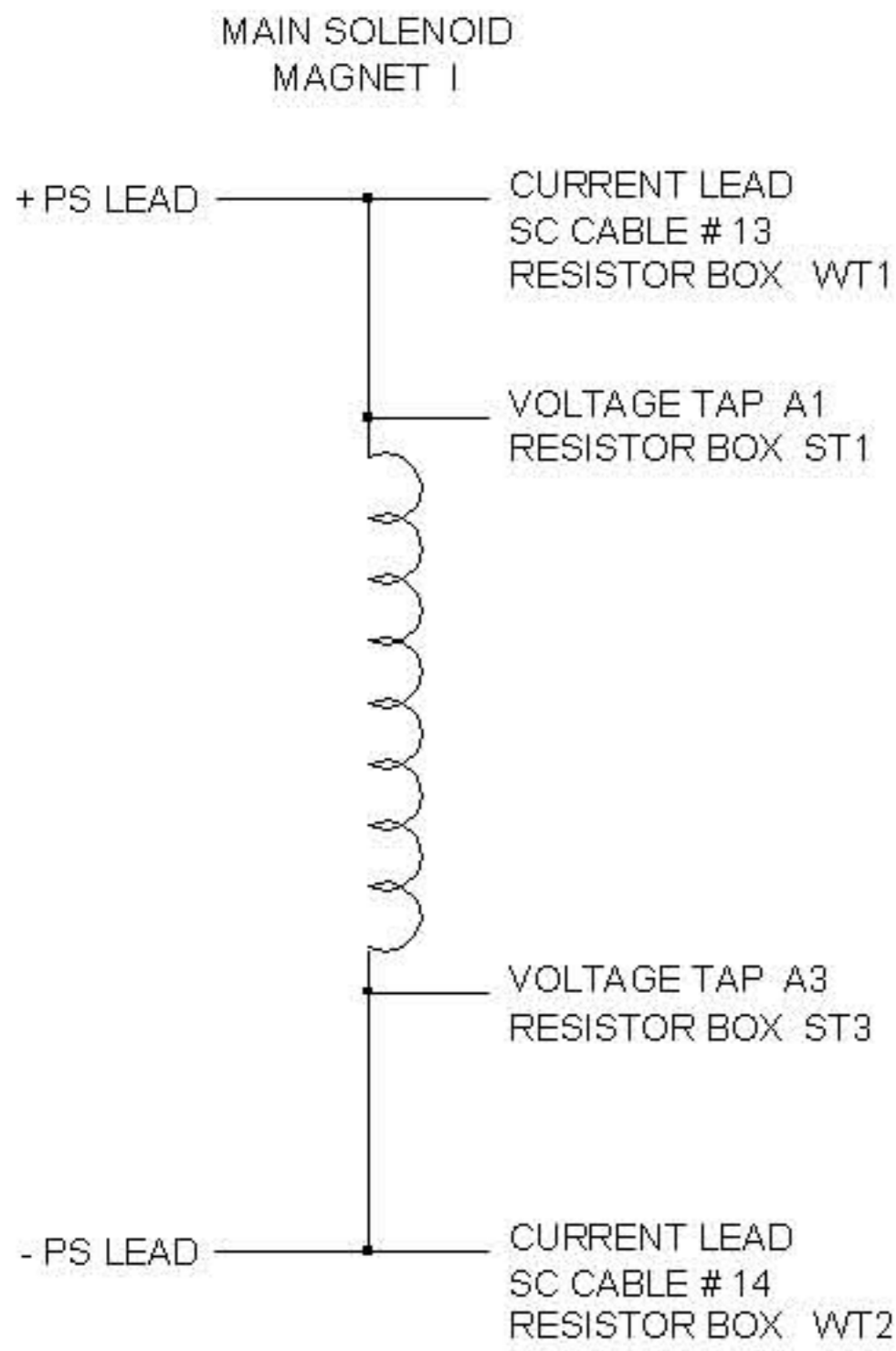
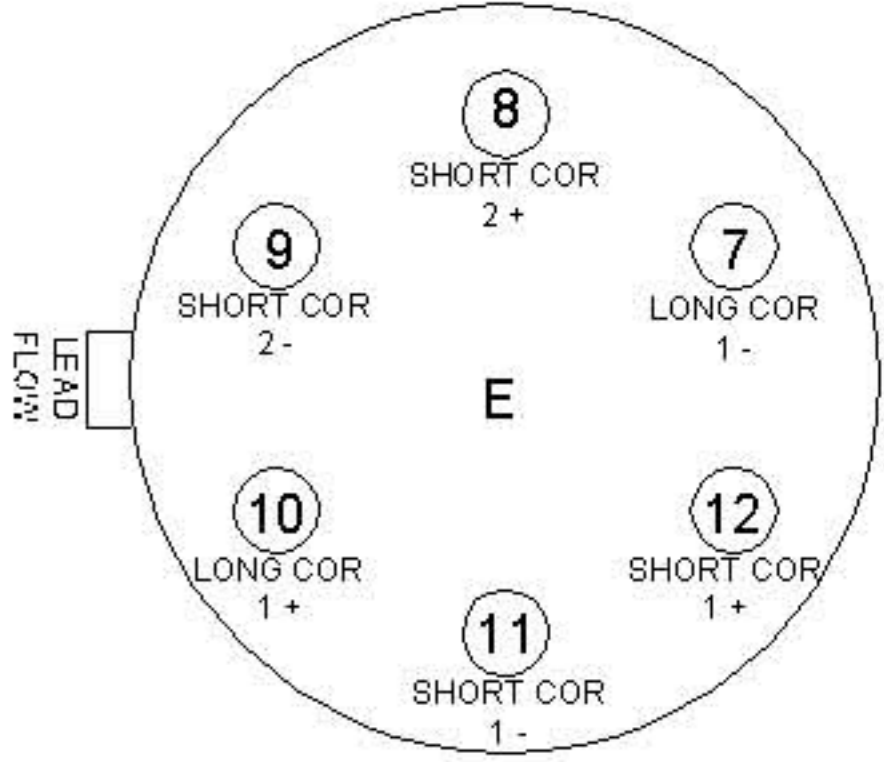
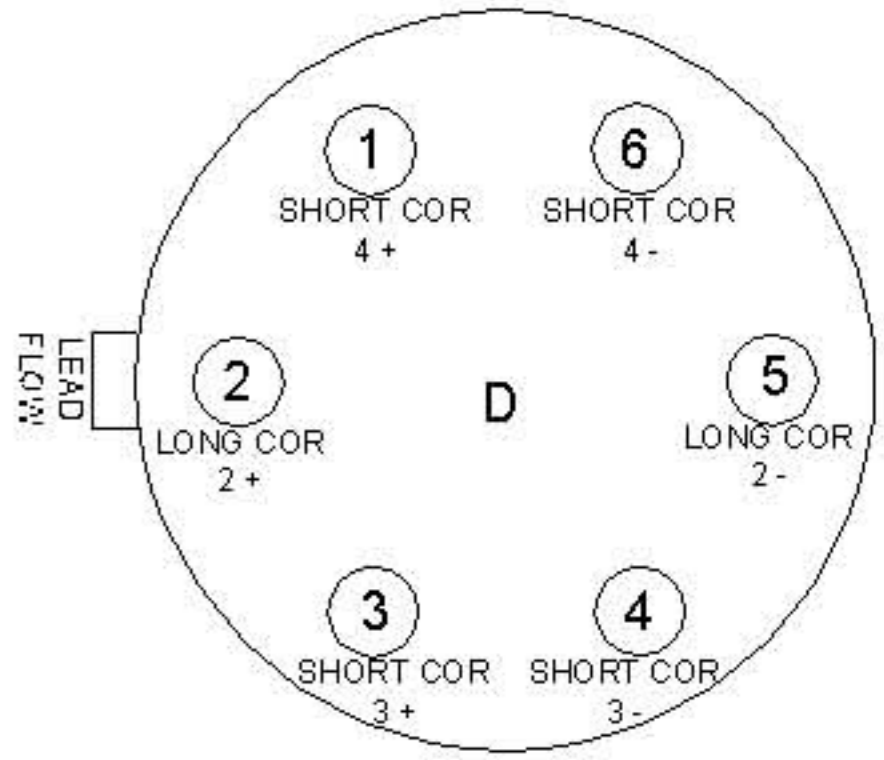
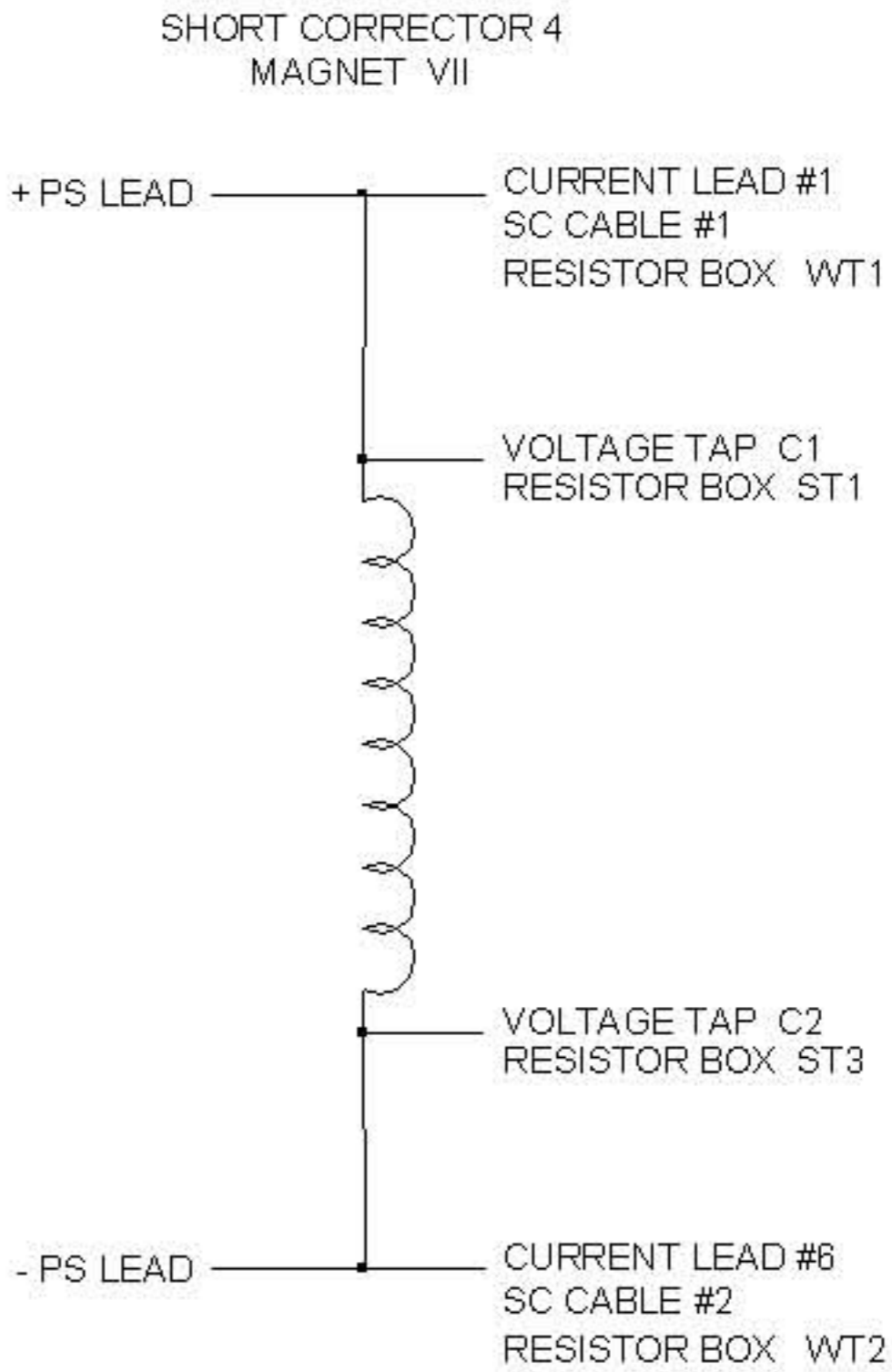
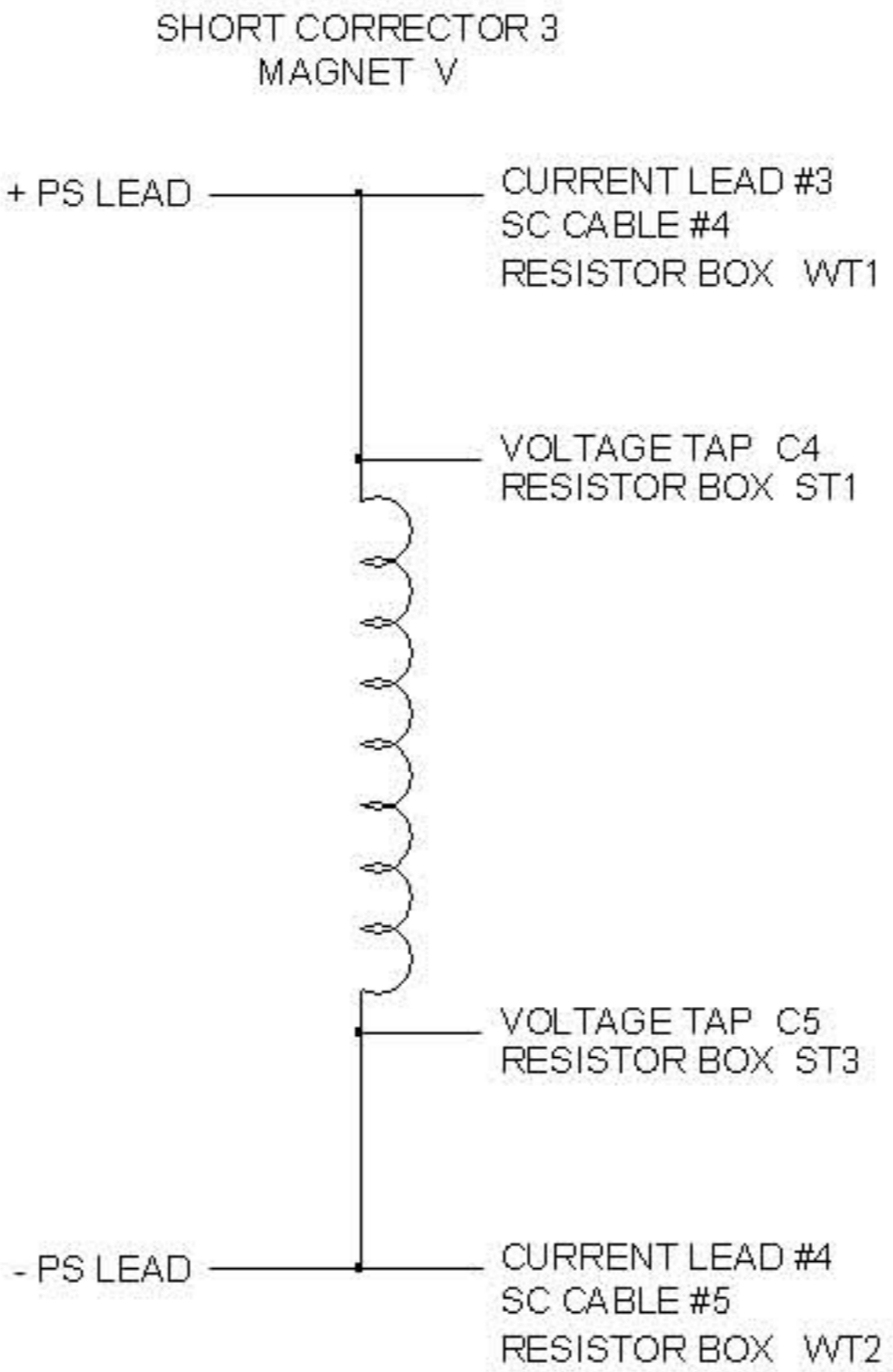
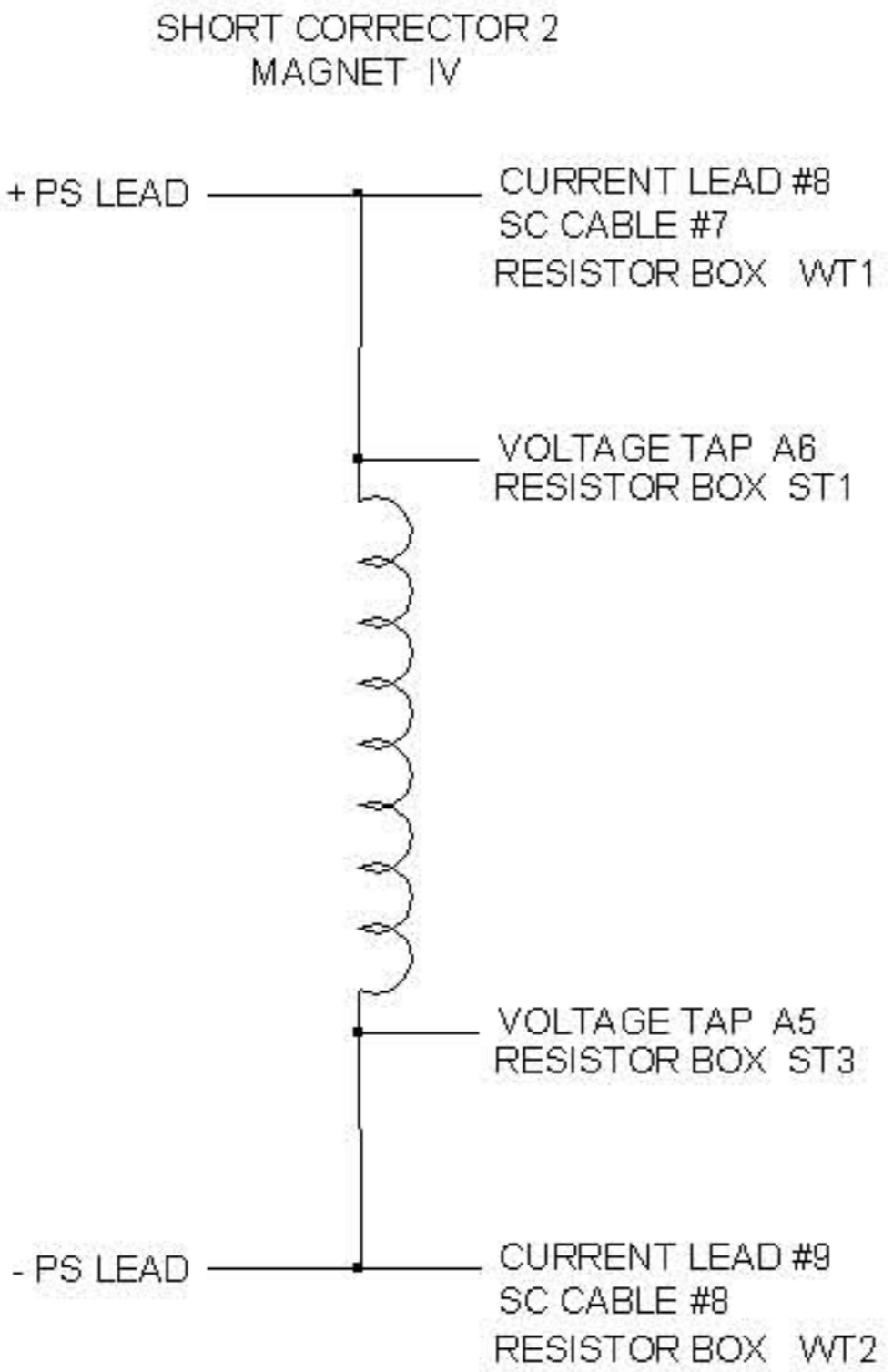
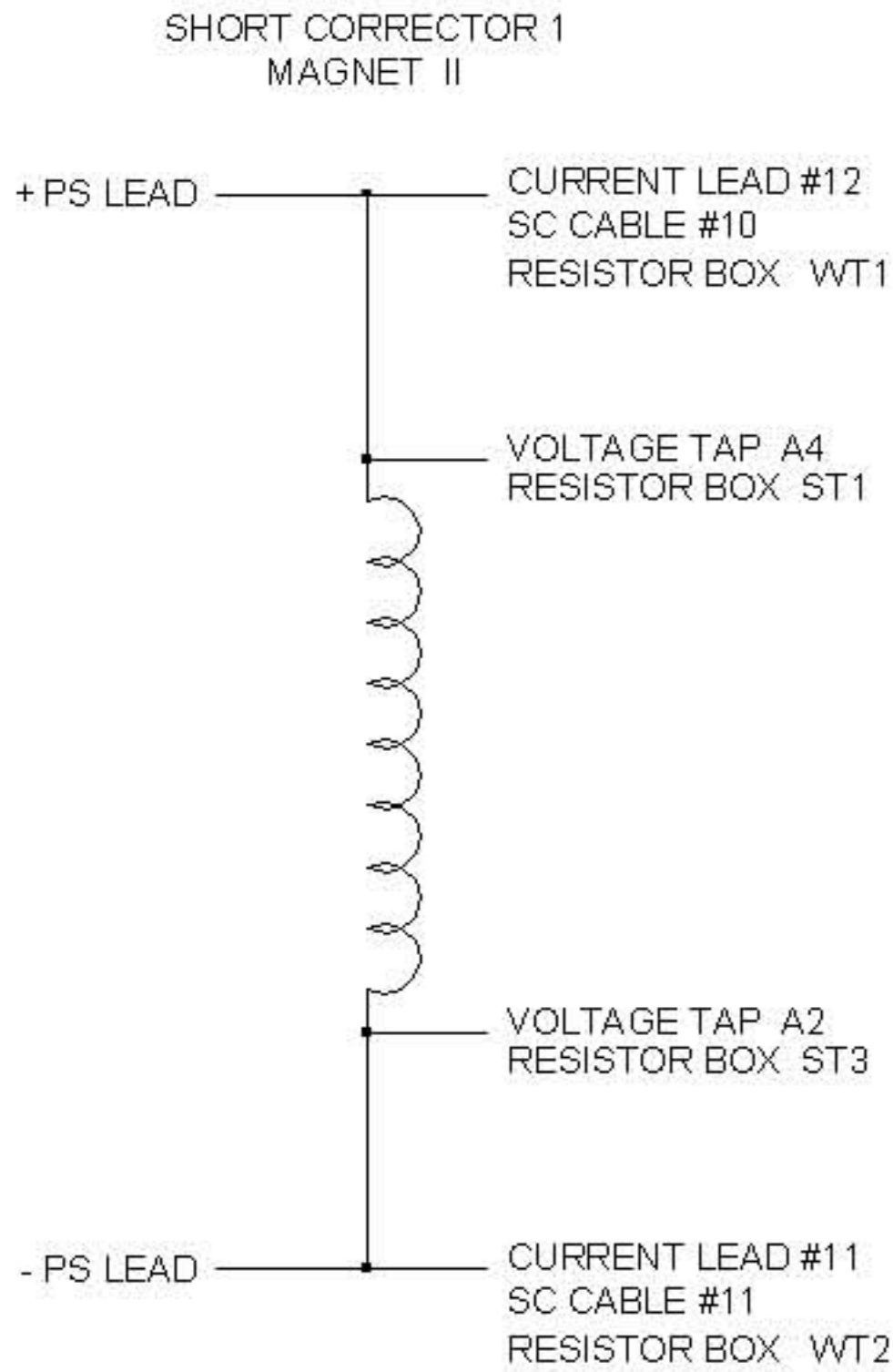
| ЛНП1128-01-01-02-0005 | |
|---|--|
| 1. Сборка осевая - см. рис. по ГОСТ 14771-78. | |
| 2. Проверка при сборке. | |
| 3. Сопоставляемость деталей должна быть по 2 и 3 параметрам. | |
| 4. Сборные узлы проверяются на герметичность в соответствии с требованиями к ним. | |

| ЛНП1128-01-01-02-0005 | |
|---|--|
| 1. Сборка осевая - см. рис. по ГОСТ 14771-78. | |
| 2. Проверка при сборке. | |
| 3. Сопоставляемость деталей должна быть по 2 и 3 параметрам. | |
| 4. Сборные узлы проверяются на герметичность в соответствии с требованиями к ним. | |

| ЛНП1128-01-01-02-0005 | |
|---|--|
| 1. Сборка осевая - см. рис. по ГОСТ 14771-78. | |
| 2. Проверка при сборке. | |
| 3. Сопоставляемость деталей должна быть по 2 и 3 параметрам. | |
| 4. Сборные узлы проверяются на герметичность в соответствии с требованиями к ним. | |

| ЛНП1128-01-01-02-0005 | |
|---|--|
| 1. Сборка осевая - см. рис. по ГОСТ 14771-78. | |
| 2. Проверка при сборке. | |
| 3. Сопоставляемость деталей должна быть по 2 и 3 параметрам. | |
| 4. Сборные узлы проверяются на герметичность в соответствии с требованиями к ним. | |

| REV | DESCRIPTION | DRAWN | DATE |
|-----|-------------|-------|------|
| | | APPD. | DATE |
| | | | |



| PRINTED CIRCUIT BOARD | |
|-----------------------|---------|
| TITLE | DWG NO. |
| SCHEMATIC | |
| ARTWORK | |
| MASTER DWG | |
| ASSEMBLY DWG | |
| OUTLINE DWG | |
| SOLDER MASK | |
| SILKSCREEN | |
| PARTS LIST | |

| ITEM NO. | PART NO. | DESCRIPTION OR SIZE | QTY. REQ. |
|--|----------|---------------------|-----------|
| PARTS LIST | | | |
| UNLESS OTHERWISE SPECIFIED | | ORIGINATOR | 10-18-00 |
| FRACTIONS | DECIMALS | DRAWN | 10-18-00 |
| °/2 | °/2 | CHECKED | |
| 1. BREAK ALL SHARP EDGES 1/8" MAX. 2. DO NOT SCALE DRAWING. 3. DIMENSIONING BY ACCORD WITH ANGLES STD. | | APPROVED | |
| ✓ MAX. ALL MACHINED SURFACE AutoCAD RELEASE 12 | | USED ON | |
| FERMI NATIONAL ACCELERATOR LABORATORY UNITED STATES DEPARTMENT OF ENERGY | | MATERIAL | |
| TEVATRON ELECTRON LENS 1 SUPER CONDUCTOR MAGNET CONNECTIONS | | SCALE | |
| -ED- | | FILED | |
| DRAWING NUMBER | | REV. | |